**NOAA's National Marine Fisheries Service**
**Endangered Species Act Section 7 Consultation**

**Biological and Conference Opinion**

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| **Agency:** | Permits, Conservation, and Education Division of the Office of Protected Resources, NOAA's National Marine Fisheries Service |
| **Activity Considered:** | The Proposal to Issue Permit No. 14344 to the University of California-Davis, Bodega Marine Laboratory, for Captive Propagation, Disease Investigations, and Experimental Field Planting of White Abalone off Southern California |
| **Consultation Conducted by:** | Endangered Species Division of the Office of Protected Resources, NOAA's National Marine Fisheries Service |
| **Approved by:** | |
| **Date:** | MAR 30 2011 |

Section 7(a)(2) of the Endangered Species Act of 1973, as amended (ESA) (16 U.S.C. 1531 *et seq.*) requires each federal agency to insure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. When a federal agency's action "may affect" listed species or designated critical habitat, that agency is required to consult formally with either NOAA's National Marine Fisheries Service (NMFS) or the U.S. Fish and Wildlife Service (USFWS), depending upon the listed resources that may be affected. Federal agencies are exempt from this requirement if they have concluded that an action "may affect", but is "unlikely to adversely affect" listed species or designated critical habitat, and NMFS and/or USFWS concur with that conclusion (50 CFR 402.14[b]).

For the actions described in this document, the action agency is NMFS' Office of Protected Resources – Permits, Conservation, and Education Division (Permits Division). The consulting agency is NMFS' Office of Protected Resources – Endangered Species Division (Endangered Species Division). This document represents NMFS' Biological and Conference Opinion (Opinion) of the effects of the proposed research activities on listed and proposed threatened and endangered species and designated critical habitat in accordance with section 7 of the ESA. This Opinion is based on information submitted by the Permits Division, published and unpublished scientific information on the biology and ecology of the listed resources affected, and other relevant sources of information.

## CONSULTATION HISTORY

On November 10, 2010, the Permits Division requested consultation with the Endangered Species Division on a proposed action to issue scientific research permit No. 14344 to the University of California-Davis (UC Davis) Bodega Marine Laboratory to conduct captive propagation, disease investigations, and experimental field planting of white abalone off southern California. The permits would be valid for five years from the date of issuance. The initiation package included the permit applications from the respective applicants, discussion of the effects of the research on the target species, drafts of the proposed permits, and the Biological Opinion written for the previous permit.

Upon reviewing the initiation package, the Endangered Species Division deemed the information sufficient and initiated formal consultation.

# BIOLOGICAL AND CONFERENCE OPINION

## DESCRIPTION OF THE PROPOSED ACTION

The Permits Division proposes to issue permit No. 14344 to UC Davis Bodega Marine Laboratory for research and enhancement of white abalone (*Haliotis sorenseni*) off the southern California coast of the U.S. pursuant to section 10(a)(1)(A) of the ESA. This action will result in direct "take"[1] of white abalone listed as endangered under the ESA. This ESA Section 7 consultation considers the effects of the proposed research studies on listed and proposed threatened and endangered species and designated critical habitat.

This permit would specifically authorize the primary researchers to maintain and expand a previously authorized captive breeding and grow-out program. The permit would also allow researchers to conduct experiments on captive white abalone progeny associated with genetics, reproduction, larval development, and disease as well as public display of white abalone in three public aquariums (Cabrillo Marine Aquarium, Ty Warner Sea Center, and Aquarium of the Pacific). Finally, the permit would authorize some small-scale experimental field planting at three predetermined sites off the coast of Santa Cruz Island in the Channel Islands region. The proposed permit would not authorize the collection of any white abalone from the wild and any wild-collected broodstock collected under prior permits would be reserved for captive propagation only and not be utilized in research experiments.

The objectives of the proposed research, laboratory cultivation, enhancement, and educational activities are as follows:

1. Increase the knowledge of the biology of white abalone.

1 The ESA defines "take" as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct

2. Identify and overcome barriers to critical stages of captive propagation (broodstock conditioning, spawning, larval rearing, settling and metamorphosis, juvenile grow-out, disease susceptibility, and treatment).

3. Develop successful field planting strategies (identify optimal field planting sites and habitat, size at planting, and cultivation methods prior to planting that reduce predation and disease susceptibility).

4. Educate and inform the public as to the role of abalone in the marine ecosystem, the impact of low density on population recovery and the current status of white abalone as an endangered species.

**Table 1** below lists the facilities associated with the proposed permit, including name of the facility, the role/activity to be authorized, and the primary contact. **Tables 2-10** then detail the proposed "take" of white abalone to be authorized for each of the facilities identified in **Table 1**. This permit would remain valid for five years after permit issuance.

**Table 1: Associated Facilities under File No. 14344**

| Facility | Role | Primary Contact |
|---|---|---|
| UC Davis Bodega Marine Laboratory | Captive Propagation and Research | Gary N. Cherr, Ph.D. |
| UC Santa Barbara Marine Laboratory | Captive Propagation and Research | Hunter Lenihan, Ph.D. |
| NMFS' Southwest Fisheries Science Center | Captive Research | John Butler, Ph.D. |
| University of Washington | Captive Research (Terminal Research) | Carolyn Friedman, Ph.D. |
| NMFS' Northwest Fisheries Science Center | Genetic Research (samples only) | Linda Park, Ph.D. |
| Scripps Institution of Oceanography | Genetic Research (samples only) | Ronald Burton, Ph.D. |
| Cabrillo Marine Aquarium | Captive Propagation and Public Display | Mike Schaadt |
| Aquarium of the Pacific | Captive Propagation and Public Display | Sandy Trautwein |
| Ty Warner Sea Center | Public Display | Amanda Hendrickson |

| Table 2: Annual Takes for the Northwest Fisheries Science Center, Seattle WA<br>Note: Receive and process frozen tissue for genetics | | | | | | |
|---|---|---|---|---|---|---|
| **SPECIES** | **PRODUCTION/ ORIGIN** | **LIFE STAGE** | **NUMBER OF ANIMALS PER YEAR** | **TAKES PER ANIMAL** | **TAKE ACTION/ PROCEDURES** | **DETAILS** |
| Abalone, white | Wild (Currently Captive) | Adult | 3 | 1 | Receive Parts | - |
| Abalone, white | Captive | All | 5000 | 1 | Receive Parts | - |

| Table 3: Annual Takes for Scripps Institution of Oceanography, La Jolla CA<br>Note: Receive and process frozen tissue for genetics | | | | | | |
|---|---|---|---|---|---|---|
| **SPECIES** | **PRODUCTION/ ORIGIN** | **LIFESTAGE** | **NUMBER OF ANIMALS PER YEAR** | **TAKES PER ANIMAL** | **TAKE ACTION/ PROCEDURES** | **DETAILS** |
| Abalone, white | Wild (Currently Captive) | Adult | 3 | 1 | Receive Parts | - |
| Abalone, white | Captive | All | 5000 | 1 | Receive Parts | - |

| Table 4: Annual Takes for Aquarium of the Pacific, Long Beach CA<br>Note: Captive Breeding, Grow-out, and Public Display (current N=6) | | | | | | |
|---|---|---|---|---|---|---|
| **SPECIES** | **PRODUCTION/ ORIGIN** | **LIFESTAGE** | **NUMBER OF ANIMALS PER YEAR** | **TAKES PER ANIMAL** | **TAKE ACTION/ PROCEDURES** | **DETAILS** |
| Abalone, white | Captive | All | 200 | 1 | Captive, breed; Captive, maintain; Mortality | Incidental Display |
| Abalone, white | Captive | Egg | 20 million | 1 | Captive, maintain; Mortality | Progeny Eggs |
| Abalone, white | Captive | Larvae | 20 million | 1 | Captive, maintain; Mortality | Progeny Larvae |
| Abalone, white | Captive | Juvenile | 10000 | 1 | Captive, lab experiments; Captive, maintain; Mortality | Progeny Juveniles |
| Abalone, white | Captive | Adult | 1000 | 1 | Captive, breed; Captive, maintain; Mortality | Progeny Adults |
| Abalone, white | All | All | Unlimited | 1 | Transfer/transport, dead | - |
| Abalone, white | All | All | Unlimited | 1 | Transfer/transport, live | - |

| Table 5: Annual Takes for Cabrillo Marine Aquarium, San Pedro CA<br>Note: Captive Breeding, Grow-out and Public Display (current N=20) | | | | | | |
|---|---|---|---|---|---|---|
| **SPECIES** | **PRODUCTION/ ORIGIN** | **LIFESTAGE** | **NUMBER OF ANIMALS PER YEAR** | **TAKES PER ANIMAL** | **TAKE ACTION/ PROCEDURES** | **DETAILS** |
| Abalone, white | Captive | All | 200 | 1 | Captive, breed; Captive, maintain; Mortality | Incidental Display |
| Abalone, white | Captive | Egg | 10 million | 1 | Captive, maintain; Mortality | Progeny Eggs |
| Abalone, white | Captive | Larvae | 10 million | 1 | Captive, maintain; Mortality | Progeny Larvae |
| Abalone, white | Captive | Juvenile | 10000 | 1 | Captive, lab experiments; Captive, maintain; Mortality | Progeny Juveniles |
| Abalone, white | Captive | Adult | 100 | 1 | Captive, breed; Captive, maintain; Mortality | Progeny Adults |
| Abalone, white | All | All | Unlimited | 1 | Transfer/transport, dead | - |
| Abalone, white | All | All | Unlimited | 1 | Transfer/transport, live | - |

| Table 6: Annual Takes for Ty Warner Sea Center, Santa Barbara CA<br>Note: Grow-out and education (current N=4) | | | | | | |
|---|---|---|---|---|---|---|
| **SPECIES** | **PRODUCTION/ ORIGIN** | **LIFESTAGE** | **NUMBER OF ANIMALS PER YEAR** | **TAKES PER ANIMAL** | **TAKE ACTION/ PROCEDURES** | **DETAILS** |
| Abalone, white | Captive | All | 200 | 1 | Captive, maintain; Mortality; Transfer/transport (dead and live) | Incidental Display |

| Table 7: Annual Takes for Bodega Marine Laboratory, White Abalone Facility | | | | | | |
|---|---|---|---|---|---|---|
| **SPECIES** | **PRODUCTION/ ORIGIN** | **LIFESTAGE** | **NUMBER OF ANIMALS PER YEAR** | **TAKES PER ANIMAL** | **TAKE ACTION/ PROCEDURES** | **DETAILS** |
| Abalone, white | Wild (Currently Captive) | Adult | 3 | 1 | Captive, breed; Captive, maintain; Mortality | Includes natural mortality only |
| Abalone, white | Captive | Egg | 40 million | 1 | Captive, maintain; Mortality | Progeny Eggs |

| Table 7: Annual Takes for Bodega Marine Laboratory, White Abalone Facility *continued* | | | | | | |
|---|---|---|---|---|---|---|
| **SPECIES** | **PRODUCTION/ ORIGIN** | **LIFESTAGE** | **NUMBER OF ANIMALS PER YEAR** | **TAKES PER ANIMAL** | **TAKE ACTION/ PROCEDURES** | **DETAILS** |
| Abalone, white | Captive | Egg | 5 million | 1 | Captive, lab experiments; Captive, maintain; Mortality | - |
| Abalone, white | Captive | Larvae | 25 million | 1 | Captive, maintain; Mortality | Progeny Larvae |
| Abalone, white | Captive | Larvae | 2 million | 1 | Captive, lab experiments; Captive, maintain; Field planting; Mortality; Observation, monitoring | No Research |
| Abalone, white | Captive | Juvenile | 30000 | 1 | Captive, lab experiments; Captive, maintain; Mortality | Progeny Juveniles |
| Abalone, white | Captive | Juvenile | 100000 | 1 | Captive, maintain; Field planting; Mortality; Observation, monitoring | - |
| Abalone, white | Captive | Adult | 100000 | 1 | Captive, breed; Captive, maintain; Mortality | Progeny Adults |
| Abalone, white | Captive | Adult | 50000 | 1 | Captive, maintain; Field planting; Mortality; Observation, monitoring | - |
| Abalone, white | Captive | Adult/ Juvenile | 6500 | 1 | Captive, lab experiments; Captive, maintain; Mortality | - |
| Abalone, white | All | All | Unlimited | 1 | Transfer/transport, dead | - |
| Abalone, white | All | All | Unlimited | 1 | Transfer/transport, live | Including animals spawned at the aquaria and UCSB facilities |

| Table 8: Annual Takes for Southwest Fisheries Science Center, La Jolla CA<br>Note: Receive and process frozen tissue for genetics | | | | | | |
|---|---|---|---|---|---|---|
| **SPECIES** | **PRODUCTION/ ORIGIN** | **LIFESTAGE** | **NUMBER OF ANIMALS PER YEAR** | **TAKES PER ANIMAL** | **TAKE ACTION/ PROCEDURES** | **DETAILS** |
| Abalone, white | Captive | Larvae | 50000 | 1 | Captive, lab experiments; Captive, maintain; Mortality; Transfer/transport (dead and live) | - |
| Abalone, white | Captive | Adult/ Juvenile | 2000 | 1 | Captive, lab experiments; Captive, maintain; Mortality; Transfer/transport (dead and live) | - |

| Table 9: Annual Takes for University of California, Santa Barbara – Marine Science Institute<br>Note: Current N = 55 | | | | | | |
|---|---|---|---|---|---|---|
| **SPECIES** | **PRODUCTION/ ORIGIN** | **LIFESTAGE** | **NUMBER OF ANIMALS PER YEAR** | **TAKES PER ANIMAL** | **TAKE ACTION/ PROCEDURES** | **DETAILS** |
| Abalone, white | Captive | Adult | 10000 | 1 | Captive, breed; Captive, maintain; Mortality | Progeny Adults |
| Abalone, white | Captive | Adult | 2000 | 1 | Captive, lab experiments; Captive, maintain; Mortality | - |
| Abalone, white | Captive | Egg | 20 million | 1 | Captive, maintain; Mortality | Progeny Eggs |
| Abalone, white | Captive | Egg | 5 million | 1 | Captive, lab experiments; Captive, maintain; Mortality | - |
| Abalone, white | Captive | Larvae | 20 million | 1 | Captive, maintain; Mortality | Progeny Larvae |
| Abalone, white | Captive | Larvae | 5 million | 1 | Captive, lab experiments; Captive, maintain; Mortality | - |
| Abalone, white | Captive | Juvenile | 10000 | 1 | Captive, maintain; Mortality | Progeny Juveniles |
| Abalone, white | Captive | Juvenile | 2000 | 1 | Captive, lab experiments; Captive, maintain; Mortality | - |

| **Table 9: Annual Takes for University of California, Santa Barbara – Marine Science Institute *continued* Note: Current N = 55** | | | | | | |
|---|---|---|---|---|---|---|
| **SPECIES** | **PRODUCTION/ ORIGIN** | **LIFESTAGE** | **NUMBER OF ANIMALS PER YEAR** | **TAKES PER ANIMAL** | **TAKE ACTION/ PROCEDURES** | **DETAILS** |
| Abalone, white | Captive | All | Unlimited | 1 | Transfer/transport, dead | - |
| Abalone, white | Captive | All | Unlimited | 1 | Transfer/transport, live | - |

| **Table 10: Annual Takes for University of Washington, School of Aquatic and Fishery Sciences, Seattle WA Note: Animals will be destroyed during research** | | | | | | |
|---|---|---|---|---|---|---|
| **SPECIES** | **PRODUCTION/ ORIGIN** | **LIFESTAGE** | **NUMBER OF ANIMALS PER YEAR** | **TAKES PER ANIMAL** | **TAKE ACTION/ PROCEDURES** | **DETAILS** |
| Abalone, white | Captive | All | 500 | 1 | Captive, lab experiments; Captive, maintain; Mortality | - |

The following is a summary of the activities to be authorized in the proposed permit. More detailed information on the research activities may be found in the application and Environmental Assessment documents associated with the proposed permit.

Captive Maintenance, Grow-out, and Propagation

Maintenance and captive propagation of white abalone will occur at four separate facilities. These facilities include the UC Davis Bodega Marine Laboratory, the UC Santa Barbara Marine Laboratory, the Cabrillo Aquarium, and the Aquarium of the Pacific. Abalone will be maintained under conditions that mimic natural conditions in the wild. Facilities used for captive propagation will utilize ambient filtered, ultra violet light (UV) irradiated seawater to prevent disease introduction and the seawater delivery systems will maintain the temperature, supply oxygen, and remove waste products to keep conditions optimal for abalone survival and growth. All land-based facilities utilized for propagation and grow-out are outside the endemic range of white abalone and the effluent is either treated with chlorine (under 10 parts per million) and dechlorinated before release or is UV irradiated to prevent impacts to the wild population occurring in offshore waters.

The intent of a captive breeding program is to produce abalone at various life stages to be used for field planting with additional individuals kept as broodstock or used for research purposes as outlined below. Captive broodstock collected under the previous permit (N=3) as well as adult progeny will be induced to spawn using UV irradiated water, hydrogen peroxide and/or thermal shock (e.g. raising or lowering temperatures to induce spawning). Genetic diversity will be maximized by conducting pair-wise mating of males and females. Larvae, juveniles, and adults from each family will be cultivated separately, or marked to protect genetic integrity. Optimal temperatures for both adults

(14-17$^{o}$C [McCormick, 2000]) and larvae (12-16$^{o}$C [Leighton, 1989]) will be maintained at each facility between spawning events.

After hatching, the larvae will feed on the yolk sac until settlement while adult and juvenile abalone will be fed fresh kelp and/or artificial feed containing algae used to enhance growth (Hooker and Morse, 1985). Larvae induced to settle on plates coated with benthic diatom films will be raised for four to six weeks (or longer) and then switched to kelp. This is the normal diet of larvae in situ. Captive-bred abalone will be marked by manipulation of the diet to produce shell banding that is useful for identifying captive bred progeny that are later used for the field planting program.

The calcium carbonate shells of abalone are a perfect substrate for boring organisms such as clams, (*Pholadidea conradi*), sponges (*Cliona* spp.) and the mud worm (*Polydora* spp.). These organisms may weaken the shell and cause irritation as the abalone repairs the inside of the shell. Shell waxing will be employed when more than 50 percent of the surface of the shell shows evidence of boring organisms. While this procedure does cause mild stress, animals will not be kept out of the water for extended periods of time (e.g. no longer than 45 minutes) and the foot and tissue on the bottom of the abalone will be kept moist to prevent desiccation in order to minimize the stress to each abalone individual.

While in captivity, abalone will be visually examined daily to monitor their health and researchers will make sure that adequate aeration and water flow are provided. Dr. Carolyn Friedman, pathologist at the University of Washington, has developed an antibiotic treatment for the control of the rickettsiales-like-protozoan (RLP) that causes withering syndrome in white abalone. Researchers will treat affected animals with Oxytetracycline (OTC) with nine injections administered over a five-week period to rid the animal of the RLP. Protocols for administering the treatment will be consistent with those established in the *NMFS White Abalone Disease and Parasite Management Plan* included in the final recovery plan for the species (NMFS, 2008). Injections have been shown to be 100 percent effective in eradicating the RLP from infected abalone, depending on the animal's level of infection prior to treatment (Friedman et al., 2003).

Captive Research Activities

Captive research activities with live white abalone will occur at four separate facilities (UC Davis Bodega Marine Lab, UC Santa Barbara Marine Lab, NMFS-SWFSC, and University of Washington) while genetic research involving white abalone samples/parts will occur at two additional facilities (NMFS' Northwest Fisheries Science Center [NMFS-NWFSC] and Scripps Institution of Oceanography). Captive research activities will yield information on the effects of abiotic (e.g., temperature, habitat type) and biotic (e.g., predator presence, food type, disease) factors on the growth and survival of white abalone from fertilization through maturation. Researchers will not use wild broodstock previously collected but will use progeny that are cultivated and maintained in the captive setting. Researchers will employ ANOVA statistical designs with 20-30 juveniles or young adults per replicate; therefore a typical experiment may test 100-500 individuals.

The following is a summary of the research topics to be investigated on captive white abalone under the proposed permit:

*Genetics*
Researchers at Scripps Institution of Oceanography believe that with a sufficient number of nuclear and mitochondrial genetic markers, it may be possible to distinguish broodstock and their offspring from wild abalone. Tissue samples will provide valuable genetic information about the population structure and to track lineage in hatchery raised stocks. A non-lethal tissue sampling methodology has been developed that uses one of the abalone's many epipodal tentacles. Researchers will use a pair of tweezers to grasp the end of one of the epipodal tentacles on the sides or posterior of the animal and then use a nail clipper to cut the tentacle 1 – 2 millimeters from its base. Samples will then be placed in a microfuge tube with 1-2 milliliters of a high salt buffer 5XNET, pH 8 solution and sent to the facilities conducting genetic testing (i.e. Scripps Institution of Oceanography and NMFS-NWFSC).

*Reproduction*
Studies of white abalone reproductive endocrinology will enable specific biomarkers (e.g. hormone titers, reproductive proteins, functional sperm biology) of reproductive readiness to be established for both males and females and determine the basis for poor male reproductive development. These techniques should help establish non-lethal sampling techniques in future years for both the laboratory and in the field. Researchers also intend to determine optimal conditions for cryopreserving both sperm and early embryos to be incorporated in future restoration efforts.

*Disease*
Researchers will conduct multiple disease experiments designed to address information gaps needed to optimize the design of future outplanting programs. They will also monitor the disease status of outplanted individuals and investigate cellular and humoral mechanisms of resistance of white abalone to withering syndrome which is a major disease threatening the survival and recovery of the wild population. Pathology testing would also be performed with captive bred animals in order to detect parasite infestation (e.g. sabellid worms), thus preventing their spread throughout the hatcheries and transmission to the wild during field planting (Friedman and Finley, 2003). Progeny exposed to this type of pathology testing are expected to be killed over the duration of the permit.

*Larval Biology*
Researchers also plan to build upon previous larval growth and settlement research by investigating the following:

- Larval survival and in relation to water temperature, salinity, and carbon dioxide concentrations;

- Larval and juvenile survival and growth on different types (functional groups) of coralline algae and in response to micro predators; and,

- Shell development.

Temperature and water quality are essential to embryonic development. Optimal temperatures along with flowing UV irradiated seawater will help to reduce mortalities of larvae during these types of research activities.

Public Display and Education

The public outreach and education program is intended to raise awareness of the ecological and economic importance of protected abalone species. Existing educational programs established at Cabrillo Marine Aquarium and the Ty Warner Sea Center will continue and the Aquarium of the Pacific will be added under the proposed permit. In addition to public display and education, these facilities also function as alternate holding facilities for grow out and act as a reserve in the event that a catastrophic failure occurs at the primary research facility. Abalone will be held in 113 liter (30 gallon) display tanks or tanks of similar size/equivalency at the three aquaria. Although the primary focus at the UC Davis Bodega Marine Laboratory will be its role as the primary grow-out and research facility, the lab receives more than 12,000 public visitors each year and white abalone will be incorporated into the existing public education program at this facility as well.

Experimental Field Planting

The only activities that will occur outside of the captive environment will be experimental field planting of captive progeny. Experimental field planting will occur at three sites located on the south side of Santa Cruz Island in the Channel Islands National Marine Sanctuary and Channel Islands National Park (along the Yellow Banks outside of the protected Gull Island Reserve area). Researchers will utilize up to 12 existing Baby Abalone Recruitment Modules (BARMs) that were designed for white abalone restoration. BARMs are located at depths of 18 – 26 meters (60 – 85 feet) and each consists of a 72 X 91 cm (or 28.5 X 36 inch) cage filled with pieces of concrete blocks. Monitoring of the BARMs has occurred at least once a year since their deployment in 2004.

Field planting will involve the release of disease- and parasite-free abalone as late-stage larvae, smaller juveniles, advanced juveniles, and young adults. Researchers will screen all individuals for disease and parasites prior to transport and every attempt will be made to place outplanted progeny within the known geographic range of parents but isolated from extant populations to prevent competition and unexpected disease transmission. A minimum of 5,000 progeny from each year class would be raised to maturity for field planting. Researchers will monitor outplanted abalone to determine effects of density and size as well as habitat and benthic community on survival.

Monitoring procedures will require surveys and sampling of both the exposed rock surfaces (most easily accomplished with ROV) and the “under rock” environment, especially for postlarvae and early juveniles (by diving and turning rocks). Destructive habitat surveys, in which the bottom structure will be disturbed, will be avoided.

Survival rates of outplanted individuals will be estimated by counting the number of empty shells in the area as well as the number of live individuals. Researchers will typically survey 1-3 months after the initial outplant, and then again at six months and thereafter at one year intervals. During scheduled surveys, BARMs will be de-constructed by divers using established procedures that prevent damage to abalone that may be present. Modules are then reassembled underwater at the end of the survey. Current estimates of survival for other species of abalone that have undergone field planting indicate a survival rate of between 1-70 percent (McCormick et al. 1994, Saito, 1984). It is expected that information gained from the experimental field planting will help researchers improve methods and strategies so that optimal survival rates may be attained.

Mitigation Measures

The following section summarizes the mitigation measures associated with permit No. 14344 to mitigate effects to targeted and any non-targeted protected species during research activities. More detailed information may be found in the associated permit and Environmental Assessment documents. The following conditions are included in the proposed permit:

1. Unspecified mortality has been authorized under certain circumstances for the progeny. These mortalities include death from natural causes, culling and authorized research, which must be included in the annual report. In the event of an unusual mortality event in the hatchery (mortality due to unique circumstances; *e.g.* disease outbreak, facility failure) or mortality equal to that authorized in the Permit, research must be immediately suspended and all relevant protocols must be reviewed, and, if necessary, revised to the satisfaction of NMFS. The Permit Holder must notify the Office of Protected Resources, Permits, Conservation and Education Division by phone within two days of the event. The Permit Holder must also submit a written incident report within 2 weeks. The Permit Holder, in consultation with NMFS, must re-evaluate the techniques that were used and those techniques must be revised accordingly to prevent further injury or death. NMFS may suspend research activities or amend this Permit in order to allow research activities to continue.

2. If authorized take is exceeded, the Researchers must cease all permitted activities and notify the Chief, NMFS Permits, Conservation, and Education Division by phone as soon as possible but not later than two business days. Researchers must also submit a written incident report within two weeks of the incident. The incident report must include a complete description of the events and identification of steps that will be taken to reduce the potential for additional exceedance of authorized take.

3. Where such non-essential photography, filming, or recording activities are authorized they must not influence the conduct of permitted activities or result in takes of protected species.

4. Researchers must comply with the following conditions related to the manner of taking:

    a. Research activities are limited to those described in the application and topic areas include reproduction, larval energetics, disease, and field planting strategies.

    b. Prior to any release of white abalone to the wild (including field planting), all protocols including disease screening, prevention of disease transmission at the facility, genetics management, field planting and monitoring must be accordingly revised based on the best available science and submitted to the Chief, Permits, Conservation and Education Division for approval.

    c. To the maximum extent possible, progeny are to be field planted within the known geographic range of parents, but isolated from extant populations.

    d. All abalone must be screened for disease and parasites prior to release or transport.

    e. Researchers should wash all field gear and equipment with fresh water between survey sites to avoid the potential introduction and spread of disease and non-indigenous species between sites.

5. For Biological Samples:

    a. The Permit Holder is responsible for all of the biological samples collected from ESA-listed species. Such samples are subject to the terms and conditions of this Permit. All samples obtained shall be identified by a unique number. All specimen materials collected or obtained under this authority shall be maintained according to accepted curatorial standards. After completion of initial research goals, any remaining samples shall be maintained by the Permit Holder or deposited into a bona fide scientific collection that meets minimum standards of collection, curation, and data cataloging as established by the scientific community.

    b. The transfer of any biological samples from the Permit Holder to researchers other than those specifically identified in the application requires written approval from the NMFS, Office of Protected Resources. Any such transfer will be subject to such conditions as NMFS, Office of Protected Resources, deems appropriate.

6. Researchers must comply with the following conditions related to methods of capture, supervision, care, and transportation:

a. All white abalone held under this Permit must remain available for research or other needs at the discretion of the Director of the Office of Protected Resources.

b. Shell waxing must only be done to animals when more than 50 percent of the surface of the shell shows evidence of boring organisms. The animal must not be out of the water longer than 45 minutes. The foot and tissue on the bottom of the abalone must be kept moist by placing the abalone on a screen that is immersed in a shallow film of water.

c. Prior to transferring white abalone to additional facilities for settlement and grow out, educational purposes and/or research, the responsible official of the facility must be designated as a co-investigator (CI) according to Condition C.5. or possess a scientific research and/or enhancement permit.

d. Prior to transfer to a new facility which has not previously held white abalone, husbandry and research protocols including disease screening and prevention of disease transmission at the facility must be submitted to the Chief, Permits, Conservation and Education Division for approval.

e. Public display of captively propagated animals is authorized provided that it is incidental to and does not interfere with the attainment of the survival or recovery objectives as described in this Permit. Such incidental public display may only occur as part of an educational program. A portion of this program must describe the research and/or enhancement activities.

f. Abalone collected from the wild must be reserved as broodstock for captive propagation and not subjected to any research that may be accomplished utilizing hatchery reared progeny.

g. For each year class, a minimum of 5,000 individuals must be raised to maturity for field planting purposes.

7. Commercial culture and sale of white abalone is forbidden.

8. The permit does not authorize takes of any protected species not identified in Part A, including those species under the jurisdiction of the USFWS. Should other protected species be encountered during the research activities authorized under this permit, researchers should exercise caution and remain a safe distance from the animal(s) to avoid take, including harassment.

9. The Permit Holder is responsible for all costs incurred by research and/or enhancement activities including determination of cause of death.

10. Disposition: The Permit Holder is responsible for excess individuals resulting from captive breeding of ESA-listed species and all disposition alternatives are subject to the terms and conditions of the Permit. The following dispositions have been considered for the Permit:

    a. Experimentally stocking in the ocean as larvae, juveniles and early adults (refer to Condition B.5.b. in the associated permit);

    b. Use in research activities (refer to Condition B.5.a. in the associated permit);

    c. Transfer to facilities for settlement and growout, educational purposes and/or research activities (refer to Condition B.7.c., B.7.d. and B.7.e. in the associated permit); and

    d. Destroying.

11. Individuals conducting permitted activities must possess qualifications commensurate with their roles and responsibilities.

12. Personnel involved in permitted activities must be reasonable in number and essential to conduct of the permitted activities.

13. Persons who require state or Federal licenses to conduct activities authorized under the permit (e.g. veterinarians, pilots) must be duly licensed when undertaking such activities.

14. Written incident reports related to serious injury and mortality events or to exceeding authorized takes, must be submitted to the Chief, Permits Division within two weeks of the incident. The incident report must include a complete description of the events and identification of steps that will be taken to reduce the potential for additional research-related mortality or exceedence of authorized take.

15. The Permit holder must submit annual reports to the Chief, NMFS Permits, Conservation, and Education Division and a final report must be submitted within 180 days after expiration of the permit, or, if the research concludes prior to permit expiration, within 180 days of completion of the research.

16. Research results must be published or otherwise made available to the scientific community in a reasonable period of time.

17. Field planting of white abalone must be coordinated with the Fish and Wildlife Service's southern sea otter recovery team to avoid predation of the abalone by sea otters.

18. The Permit Holder must provide written notification of planned field work to the appropriate Assistant Regional Administrator(s) for Protected Resources. Such notification must be made at least two weeks prior to initiation of a field trip/season and must include the locations of the intended field study and/or survey routes, estimated dates of research, and number and roles of participants.

19. To the maximum extent practicable, the Permit Holder must coordinate permitted activities with activities of other Permit Holders conducting the same or similar activities on the same species, in the same locations, or at the same times of year to avoid unnecessary disturbance of animals.

## APPROACH TO THE ASSESSMENT

NMFS approaches its section 7 analyses of agency actions through a series of steps. The first step identifies those aspects of proposed actions that are likely to have direct and indirect physical, chemical, and biotic effects on listed species or on the physical, chemical, and biotic environment of an action area. As part of this step, we identify the spatial extent of these direct and indirect effects, including changes in that spatial extent over time. The result of this step includes defining the *Action Area* for the consultation. The second step of our analyses identifies the listed resources that are likely to co-occur with these effects in space and time and the nature of that co-occurrence (these represent our *Exposure Analyses*). In this step of our analyses, we try to identify the number, age (or life stage), and gender of the individuals that are likely to be exposed to an action's effects and the populations or subpopulations those individuals represent. Once we identify which listed resources are likely to be exposed to an action's effects and the nature of that exposure, we examine the scientific and commercial data available to determine whether and how those listed resources are likely to respond given their exposure (these represent our *Response Analyses*).

The final steps of our analyses establishes the risks those responses pose to listed resources (these represent our *Risk Analyses*). Our jeopardy determinations must be based on an action's effects on the continued existence of threatened or endangered species as those "species" have been listed, which can include true biological species, subspecies, or Distinct Population Segments (DPSs) of species. The continued existence of these "species" depends on the fate of the populations that comprise them. Similarly, the continued existence of populations are determined by the fate of the individuals that comprise them – populations grow or decline as the individuals that comprise the population live, die, grow, mature, migrate, and reproduce (or fail to do so).

Our risk analyses reflect these relationships between listed species, the populations that comprise that species, and the individuals that comprise those populations. Our risk analyses begin by identifying the probable risks actions pose to listed individuals that are likely to be exposed to an action's effects. Our analyses then integrate those individual risks to identify consequences to the populations those individuals represent. Our

analyses conclude by determining the consequences of those population-level risks to the species those populations comprise.

We measure risks to listed individuals using the individuals' "fitness," or the individual's growth, survival, annual reproductive success, and lifetime reproductive success. In particular, we examine the scientific and commercial data available to determine if an individual's probable lethal, sub-lethal, or behavioral responses to an action's effect on the environment (which we identify during our *Response Analyses*) are likely to have consequences for the individual's fitness.

When individual listed plants or animals are expected to experience reductions in fitness in response to an action, those fitness reductions are likely to reduce the abundance, reproduction, or growth rates (or increase the variance in these measures) of the populations those individuals represent (see Stearns, 1992). Reductions in at least one of these variables (or one of the variables we derive from them) is a necessary condition for reductions in a population's viability, which is itself a necessary condition for reductions in a species' viability. As a result, when listed plants or animals exposed to an action's effects are not expected to experience reductions in fitness, we would not expect the action to have adverse consequences on the viability of the populations those individuals represent or the species those populations comprise (e.g., Brandon, 1978; Mills and Beatty, 1979; Stearns, 1992; Anderson, 2000). As a result, if we conclude that listed plants or animals are not likely to experience reductions in their fitness, we would conclude our assessment.

Although reductions in fitness of individuals is a *necessary* condition for reductions in a population's viability, reducing the fitness of individuals in a population is not always *sufficient* to reduce the viability of the population(s) those individuals represent. Therefore, if we conclude that listed plants or animals are likely to experience reductions in their fitness, we determine whether those fitness reductions are likely to reduce the viability of the populations the individuals represent (measured using changes in the populations' abundance, reproduction, spatial structure and connectivity, growth rates, variance in these measures, or measures of extinction risk). In this step of our analyses, we use the population's base condition (established in the *Environmental Baseline* and *Status of the Species* sections) as our point of reference. If we conclude that reductions in the fitness of individuals are not likely to reduce the viability of the populations those individuals represent, we would conclude our assessment.

Reducing the viability of a population is not always *sufficient* to reduce the viability of the species those populations comprise. Therefore, in the final step of our analyses, we determine if reductions in a population's viability are likely to reduce the viability of the species those populations comprise using changes in a species' reproduction, numbers, distribution, estimates of extinction risk, or probability of being conserved. In this step of our analyses, we use the species' status (established in the *Status of the Species* section) as our point of reference. Our final jeopardy determinations are based on whether threatened or endangered species are likely to experience reductions in their viability and whether such reductions are likely to be appreciable.

Destruction or adverse modification determinations must be based on an action‘s effects on the conservation value of habitat that has been designated as critical to threatened or endangered species. If an area encompassed in a critical habitat designation is likely to be exposed to the direct or indirect consequences of the proposed action on the natural environment, we ask if primary or secondary constituent elements included in the designation (if there are any) or physical, chemical, or biotic phenomena that give the designated area value for the conservation of listed species are likely to respond to that exposure. If primary or secondary constituent elements of designated critical habitat (or physical, chemical, or biotic phenomena that give the designated area value for the conservation of listed species) are likely to respond given exposure to the direct or indirect consequences of the proposed action on the natural environment, we ask if those responses are likely to be sufficient to reduce the quantity, quality, or availability of those constituent elements or physical, chemical, or biotic phenomena.

If the quantity, quality, or availability of the primary or secondary constituent elements of the area of designated critical habitat (or physical, chemical, or biotic phenomena) are reduced, we ask if those reductions are likely to be sufficient to reduce the conservation value of the designated critical habitat for listed species in the action area. In this step of our assessment, we combine information about the contribution of constituent elements of critical habitat (or of the physical, chemical, or biotic phenomena that give the designated area value for the conservation of listed species) to the conservation value of those areas of critical habitat that occur in the action area, given the physical, chemical, biotic, and ecological processes that produce and maintain those constituent elements in the action area.

If the conservation value of designated critical habitat in an action area is reduced, the final step of our analyses asks if those reductions are likely to be sufficient to reduce the conservation value of the entire critical habitat designation. In this step of our assessment, we combine information about the constituent elements of critical habitat (or of the physical, chemical, or biotic phenomena that give the designated area value for the conservation of listed species) that are likely to experience changes in quantity, quality, and availability given exposure to an action with information on the physical, chemical, biotic, and ecological processes that produce and maintain those constituent elements in the action area. We use the conservation value of the entire designated critical habitat as our point of reference for this comparison. For example, if the designated critical habitat has limited current value or potential value for the conservation of listed species that limited value is our point of reference for our assessment.

To conduct these analyses, we rely on all of the evidence available to us. This evidence might consist of monitoring reports submitted by past and present permit holders, reports from NMFS Science Centers, reports prepared by State or Tribal natural resource agencies, reports from non-governmental organizations involved in marine conservation issues, the information provided by the Permits, Conservation and Education Division when it initiates formal consultation, and the general scientific literature. We supplement this evidence with reports and other documents – environmental assessments,

environmental impact statements, and monitoring reports – prepared by other federal and state agencies like the Minerals Management Service, U.S. Coast Guard and U.S. Navy whose operations extend into the marine environment.

During each consultation, we conduct electronic searches of the general scientific literature using *American Fisheries Society*, *Google Scholar*, *ScienceDirect*, *BioOne*, *Conference Papers Index*, *JSTOR*, and *Aquatic Sciences and Fisheries Abstracts* search engines. We supplement these searches with electronic searches of doctoral dissertations and master's theses. These searches specifically try to identify data or other information that supports a particular conclusion as well as data that does not support that conclusion.

We rank the results of these searches based on the quality of their study design, sample sizes, level of scrutiny prior to and during publication, and study results. Carefully designed field experiments (for example, experiments that control potentially confounding variables) are rated higher than field experiments that are not designed to control those variables. Carefully designed field experiments are generally ranked higher than computer simulations. Studies that produce large sample sizes with small variances are generally ranked higher than studies with small sample sizes or large variances. Finally, in keeping with the direction from the U.S. Congress to provide the "benefit of the doubt" to threatened and endangered species [House of Representatives Conference Report No. 697, 96th Congress, Second Session, 12 (1979)], when data are equivocal, or in the face of substantial uncertainty, our decisions are designed to avoid the risks associated with incorrectly concluding an action has no adverse effect on a listed species when, in fact, such adverse effects are likely (i.e. avoiding Type II error).

## ACTION AREA

The action area is defined in 50 CFR 402.2 as "all areas to be affected directly or indirectly by the Federal Action and not merely the immediate area involved in the action." The action area for this consultation consists of three separate areas along the U.S. west coast: southern California, northern California, and northern Washington state. Captive research and propagation will occur at the UC Davis Bodega Bay Marine Laboratory in northern California as well as at UC Santa Barbara and NMFS-SEFSC in southern California. Research on terminal disease will occur at the University of Washington while samples for genetic analyses will be sent to NMFS' Northwest Fisheries Science Center (NMFS-NWFSC) in Seattle and Scripps Institution of Oceanography in southern California. Cabrillo Marine Aquarium, the Ty Warner Sea Center and the Aquarium of the Pacific in southern California will hold excess progeny for grow-out and public display with Cabrillo Marine Aquarium and Aquarium of the Pacific also captively breeding animals held at their respective facilities. Finally, some experimental field planting will occur in southern California off the Channel Islands (specifically three sites on the south side of Santa Cruz Island). This is the only portion of the action area occurring offshore. All three major areas contained in this action area are connected through their transit routes.

The area extending approximately 1,000 kilometers (km) from Point Conception southward past San Diego is a region referred to as the Southern California Bight (SCB). The SCB represents all of the U.S. range of white abalone and approximately half of the entire range (U.S. and Mexican) of white abalone. In California, especially southern California, kelp forests cover most rocky subtidal habitats. The highly productive ecosystem organized around the giant kelp (*Macrocystis pyrifera*) supports the commercial harvest of kelp, red abalone, sea urchins, spiny lobsters, rock crabs, and finfishes. The large standing stocks of kelp with high rates of growth, production, and turnover supply algal drift, which represent abundant and relatively predictable food sources for populations of white abalone. The continental shelf along the SCB is very narrow (less than 10 km), and at its widest, extends about 300 km from the mainland. Along the mainland coast, the dominant nearshore habitat is sandy beach, while along the offshore Channel Islands, the shores are predominantly rocky. The benthos consists of soft sediment with patches of rocky outcrops, which is the preferred habitat of white abalone.

## STATUS OF THE SPECIES

NMFS' Office of Protected Resources – Endangered Species Division has determined that the following listed resources provided protection under the ESA occur within the action area and may be affected by proposed action:

| Common Name | Scientific Name | Listing Status |
|---|---|---|
| White abalone | *Haliotis sorenseni* | Endangered |
| Black abalone | *Haliotis cracherodii* | Endangered |
| Guadalupe fur seal | *Arctocephalus townsendi* | Threatened |
| North Pacific Right whale | *Eubalaena japonica* | Endangered |
| Blue whale | *Balaenoptera musculus* | Endangered |
| Fin whale | *Balaenoptera physalus* | Endangered |
| Humpback whale | *Megaptera novaeangliae* | Endangered |
| Sperm whale | *Physeter macrocephalus* | Endangered |
| Sei whale | *Balaenoptera borealis* | Endangered |
| Steelhead trout (Southern California Distinct Population Segment) | *Oncorhynchus mykiss* | Endangered |
| Leatherback sea turtle | *Dermochelys coriacea* | Endangered |
| Hawksbill sea turtle | *Eretmochelys imbricata* | Endangered |
| Green sea turtle | *Chelonia mydas* | Endangered[2] |
| Olive Ridley sea turtle | *Lepidochelys olivacea* | Threatened |
| Loggerhead sea turtle | *Caretta caretta* | Threatened |
| Loggerhead sea turtle (North Pacific Ocean Distinct Population Segment) | *Caretta caretta* | Proposed Endangered[3] |

2 Green sea turtles in U.S. waters are listed as threatened except for the Florida breeding population, which is listed as endangered. Due to difficulties in distinguishing between individuals from the Florida population from other populations, green sea turtles are considered endangered wherever they occur in U.S. waters.

| | |
|---|---|
| Leatherback sea turtle critical habitat | Areas Proposed for Designation |
| Black abalone critical habitat | Areas Proposed for Designation |

Listed Resources Not Likely to be Adversely Affected

The research applicants may encounter five species of listed sea turtles (leatherback, hawksbill, green, olive ridley, and loggerhead), one species of sea turtle proposed for listing (loggerhead sea turtle North Pacific Ocean DPS), six species of listed whales (North Pacific right, blue, fin, humpback, sperm, and sei), one listed anadromous fish species (Steelhead Trout Southern California DPS), and one listed seal species (Guadalupe fur seal) during transit as well as during field planting and monitoring of white abalone off Santa Cruz Island. However, the proposed research activities are targeted at three specific sites on the south side of the island and no activities would occur further offshore. Therefore, the Endangered Species Division believes that interactions with and threats to these listed resources are extremely unlikely and therefore discountable. Researchers would take necessary action to avoid harassing any sea turtle or marine mammal if encountered. Thus, the proposed action is not likely to adversely affect any listed sea turtle, whale, seal, or anadromous fish species and these species will not be considered further in this Opinion.

Sites targeted for experimental field planting of white abalone occur within critical habitat proposed for leatherback sea turtles. There are two primary constituent elements identified in the proposed critical habitat revisions that are essential for the conservation of leatherbacks in marine waters off the U.S. West Coast: (1) occurrence of prey species, primarily scyphomedusae of the order Semaeostomeae (*Chrysaora, Aurelia, Phacellophora,* and *Cyanea*) of sufficient condition, distribution, diversity, and abundance to support individual as well as population growth, reproduction, and development; and (2) Migratory pathway conditions to allow for safe and timely passage and access to/from/within high use foraging areas. The proposed research is not expected to affect prey abundance or distribution nor would it affect migratory pathway conditions for leatherback sea turtles traveling to and from high use foraging areas. Researchers are expected to avoid interaction with leatherback sea turtles in the event any individuals are encountered. Therefore, the proposed research should not affect proposed critical habitat for leatherback sea turtles and this resource will not be considered further in this Opinion.

Black abalone, including portions of proposed critical habitat for the species occurs in nearshore habitats within the action area and could potentially be disturbed by the proposed research during transit and field planting of white abalone progeny off Santa Cruz Island. However, black abalone typically inhabit coastal and offshore island rocky intertidal habitats from the mean higher high water line to depths of six meters (Leighton, 2005) and the lateral extent of the proposed critical habitat designation offshore is defined by the six meter depth bathymetry contour relative to the line of mean lower low

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3 The loggerhead sea turtle is listed as threatened throughout its range; however, NMFS and USFWS has currently proposed nine distinct population segments under the ESA. Two are proposed as threatened (South Atlantic Ocean and Southwest Indian Ocean) while the other seven are proposed as endangered (Mediterranean Sea, North Indian Ocean, North Pacific Ocean, Northeast Atlantic Ocean, Northwest Atlantic Ocean, South Pacific Ocean, and Southeast Indo-Pacific Ocean).

water and shoreward to the mean higher high water line. Therefore, since the white abalone BARMs occur at depths of 18-26 meters, they are well outside of the lateral boundary of the critical habitat proposed for black abalone and occur at depths that do not typically support black abalone individuals. PCEs for the proposed black abalone critical habitat include: (1) Suitable rocky substrate (i.e. rocky benches formed from consolidated rock of various geological origins that contain channels with macro- and micro-crevices or large boulders and occur from mean higher high water to a depth of six meters); (2) Abundant food resources including bacterial and diatom films, crustose coralline algae, and a source of detrital macroalgae; (3) Juvenile settlement habitat (i.e. rocky intertidal habitat containing crustose coralline algae and crevices or cryptic biogenic structures; (4) Suitable water quality necessary for normal settlement, growth, behavior, and viability of black abalone; and (5) Suitable nearshore circulation patterns that retain eggs, sperm, fertilized eggs and ready-to-settle larvae so that successful fertilization and settlement to suitable habitat can take place. Given that the research is targeted for habitat conditions suitable for white abalone, NMFS believes that exposure of black abalone and its proposed critical habitat to effects of the proposed action are highly unlikely and therefore discountable. All white abalone grown in captivity will be screened for disease prior to field planting to avoid possible disease transmission to wild abalone species and the presence of outplanted white abalone is expected to have a negligible impact on food availability for other abalone species including black abalone. Therefore, NMFS believes that the proposed research is not likely to adversely affect black abalone and/or its proposed critical habitat and these resources will not be considered further in this Opinion.

Listed Resources Likely to be Adversely Affected

The sections below provide information on the status of listed resources likely to be adversely affected by the proposed action (i.e. white abalone). The biology and ecology of this species as well as its global status and trends are described below, and inform the effects analysis for this Opinion.

***White Abalone***

*Species Description, Distribution, and Population Structure*

White abalone are marine gastropods characterized by soft bodies, a mantle which secretes their shells, anterior heads, and a large muscular foot. Their shells are generally deep, thin, and light-weight with a number of highly elevated respiratory pores. Typically, the shell's interior is a pearly white and contains a poorly differentiated or absent muscle scar (Cox, 1962). The muscular foot is capable of strong suction which allows the abalone to firmly anchor itself on rocky surfaces. The foot is surrounded by the epipodium, a sensory structure that bears beige or tan tentacles and protrudes beyond the shell edge. White abalone can reach 20-25.4 centimeters (or 7.9-10 inches) in length but more commonly are found between 12.7- 20.3 centimeters (or 5-8 inches) in the U.S. and around 17 centimeters (6.7 inches) in Mexican waters (Hobday and Tegner, 2000).

White abalone occur on the west coast of the U.S. along offshore islands and banks (particularly Santa Catalina and San Clemente islands) and along the mainland shores from Point Conception, California south to Punta Abreojos, Baja California, Mexico

(NMFS, 2008). Adults occur in open, low relief rocky reefs or boulder habitat surrounded by sand (Hobday and Tegner, 2000). Suitable habitat is patchy, thus, the distribution of white abalone is also patchy (NMFS, 2008). Adult white abalone may be found at depths ranging from 5-60 meters, making them the deepest living of the abalone species found off the U.S. west coast (Cox, 1960). Current remnant populations are most common between 30-60 meters depth and a recent survey by Butler et al. (2006) found the highest densities at depths of 40-50 meters. Factors controlling the depth distribution of white abalone are poorly known. Biological factors, such as competition and predation, have been implicated as factors controlling the upper limit, while water temperature and food availability have been implicated as factors controlling the lower limit (Hobday and Tegner, 2000). Tutschulte (1976) speculated that white abalone may have been restricted to deeper waters as a result of sea otter predation or competition from pink abalone. Human fishing activities may have also contributed to this deeper depth distribution.

There has been limited genetic testing suggesting that white abalone are one population (Butler and Hunter, 2002), but the sample size was small (n=13) and all samples were from one offshore bank. There is a possible subspecies of white abalone found at Guadalupe Island (Mexico), although it has not been formally described (Howorth, 1978). Despite this dearth in information regarding white abalone population structure, we can compare white abalone with other species of California abalone that have undergone some genetic testing (i.e., red and black abalone). Red abalone exist as a single population while black abalone indicate considerable genetic differences and a discrete sub-population structure (Hamm and Burton, 2000). The differences in population structure indicated within the red and black abalone species may be attributed to spawning frequency and the range of oceanographic conditions experienced by larvae during critical life stages. For example, red abalone spawn year round and larvae are exposed to a full cycle of seasonal oceanic conditions whereas black abalone spawn only during the summer and larvae are only exposed to the oceanic conditions during that period (Hamm and Burton, 2000). White abalone, like black abalone, have a short spawning season indicating that the genetic structure of the population could be quite complex. Based on the limited genetic testing and the similarity of spawning frequencies between white and black abalone we will assume for the purposes of this Opinion that white abalone exist in discrete sub-populations.

*Life History Information*

Abalone are broadcast spawners where males and females aggregate together and release gametes into the water column for fertilization. The gametes are released through the respiratory holes with the respiratory current. Spawning is highly synchronous (i.e. gametes are released at the same time) and occurs once a year from February to April (Tutschulte, 1976).

Cues that stimulate white abalone spawning are unknown but appear to be relatively short lived and may be chemical (bioactive triggers) or physical (abrupt temperature changes [Leighton, 2000]). Possible factors affecting spawning include temperature, salinity, tidal rhythm, lunar periodicity, and surf (Giese and Pearse, 1977) which can influence the

initiation and length of the spawning season and synchronicity of the spawning event (Counihan et al., 2001). The presence of the opposite sex also greatly increases spawning synchronicity and can increase the volume of gametes released into the water column (Hooker and Morse, 1985; McCormick, 2000).

Based on gonad volume and oocyte density, white abalone from Catalina Island, when compared with green and pink abalone, had a very high fecundity at 3.69-6.53 x $10^6$ total eggs released (Tutshulte and Connell, 1981). White abalone have been shown to exhibit higher fecundity with increased size so as they age, their reproductive potential also increases (Tutschulte, 1976; Tegner, 1989; Leighton, 2000). An average female may produce over 20 million larvae throughout their lifetime (assuming all ova are fertilized and develop normally), and larval survival to adulthood is estimated at less than one percent (Leighton, 2000).

Twenty-four hours after fertilization, the free-living trochophore larvae displays a negative geotaxis when it emerges from the egg and swims in the plankton (Leighton, 1989). This stage does not actively feed but instead survives on its own yolk sac (Leighton, 2000). This stage remains in the plankton for approximately two to three weeks swimming through the upper 10 meters of the water column until it is induced to settle (Leighton, 2000). Settlement is thought to be induced by a chemical produced by abalone and coralline algae, but other unknown environmental cues may also play a role in the selection of a settlement site (Shepherd and Turner, 1985; Slattery, 1992; Daume et al., 1999).

The post-larval abalone begins to feed as the juvenile form takes shape. Small juveniles feed on benthic diatoms, bacterial films and other benthic microflora. Generally, abalone are cryptic and photophobic in nature until they are about 3-5 years old or when they reach a size of 75-100 millimeters (Cox, 1962). Juveniles of this size and smaller occur in rock crevices, under rocks and even under the cover of adult red sea urchin spines (Tegner, 1989). Abalone larger than 100 millimeters are classified as “emergent” abalone as they leave sheltered habitats and move to more open habitat to forage on attached or drifting macroalgae. Juvenile and adult white abalone, while not exclusively nocturnal, generally feed during the night (Leighton, 2000).

White abalone become sexually mature when they reach sizes of approximately 88-134 millimeters or between 4 –6 years of age (Tutschulte and Connell, 1981). Adults reach a maximum size of 200-254 millimeters during their lifetime (Cox, 1960), and have an average lifespan of 35-40 years (Tutschulte, 1976). Growth rates for adults (n=3) fed on *Macrocystis* have been measured at 16.4 ± 7.8 millimeters/year in the laboratory setting (Tutschulte, 1976). Adult abalone feed primarily on drift algae but will also feed on attached macroalgae, using their radula and mouth parts to graze algae from rocky substrates. Drift algae is captured with the anterior portion of the foot and brought to the mouth. Tutschulte (1976) studied the movements of white, pink and green abalone on Santa Catalina Island and concluded that adult white abalone made minimal movements and were more sedentary compared to other abalone species.

*Listing Status*
White abalone is listed as endangered throughout its range from Point Conception, California to Punta Abreojos, Baja California, Mexico (66 FR 29046, May 29, 2001). No critical habitat has been designated.

*Status and Trends*
White abalone abundance has declined significantly throughout its range as a result of overutilization for commercial and recreational purposes (Estes and VanBlaricom, 1985; Hobday and Tegner, 2000). Hobday and Tegner (2000) estimated pre-exploitation abundance at 2,221,800 abalone individuals and used surveys conducted by Davis et al. (1998) to estimate the 1996-1997 white abalone population at 1,613 individuals. This represented a 99.9 percent decline from pre-exploitation levels. In 2001, Hobday et al. (2001) updated the 1996-1997 white abalone abundance estimate at 2,540 individuals using surveys conducted in 1972, 1980-81, 1992-93, 1996-97, and 1999. More recently, Butler et al. (2006) conducted two surveys in 2002 and 2003 and their results were significantly higher at 15,187 and 22,123 white abalone, respectively, for two offshore banks and one island location off southern California. The researchers attributed the increase due to the use of multibeam sonar mapping technology revealing more habitat than was previously known to exist, and by not including portions of surveys that were inappropriate habitat (e.g. sand) when calculating densities. Surveys of abalone populations and resulting abundance and density estimates only account for mature abalone and may not reflect the true abundance of the population although the numbers reported by Butler et al. (2006) represent the most recent data available at the time of this consultation. Nevertheless, current estimates reveal that white abalone population numbers remain critically low compared to pre-exploitation numbers.

Due to their life history characteristics as long-lived, slow moving bottom dwellers with external fertilization, white abalone were particularly susceptible to local and subsequent serial depletion by fishermen. Region-wide landings of white abalone peaked at 144,000 pounds (65,318 kilograms) in 1972 after only 3 years of commercial exploitation, and declined to less than 10,000 pounds (4,535 kilograms) by 1977. By 1978, white abalone landings were so negligible (less than 1,000 pounds or 454 kilograms) that the California Department of Fish and Game no longer collected landings data for the species (NMFS, 2008). White abalone catch data from California indicate that over 80 percent of the landings were taken from San Clemente Island while the offshore Tanner Bank and Cortes Bank-Bishop Rock region provided an additional 13 percent of the total catch. Between 1965 and 1975, over 25 percent (average 43 percent) of the white abalone catch in each area came during just a single year (Hobday and Tegner, 2000), showing the drastic impact that short term commercial exploitation had on population levels. It has been suggested that the increasing value of abalone meat may have contributed to increased fishing effort during that time even as total landings began to decrease (Estes and VanBlaricom, 1985; Hobday and Tegner, 2000; Karpov et al., 2000).

In Mexico, landings of white abalone essentially mirrored the declines seen for U.S. fisheries. At Isla La Natividad, Baja, California, the fishery for abalone was dominated with catches of red abalone, but as red abalone catches declined, white and green abalone

were increasingly targeted (Shepherd et al., 1998). Based on the limited information available, it is likely that the white abalone population in Mexico has been declining since the 1970s and some have suggested that densities have declined to a level at which recruitment failure has already occurred in some areas (Hobday and Tegner, 2000). Illegal harvest of undersized white abalone is still seen as a problem in Mexico, but the extent of the problem remains uncertain due to scant data (NMFS, 2008).

Intense fishing pressure is likely the primarily cause for producing critically low densities in populations throughout most of the species' historic range in southern California. Low density has likely led to repeated recruitment failure and reduced genetic diversity within and across populations of white abalone in California. There are no studies on the minimum density of aggregations needed for white abalone to ensure successful fertilization; however, Babcock and Keesing (1999) conducted lab and field studies with Australian abalone which indicated that fertilization could be limited when abalone are more than two meters apart or when densities fall below 0.3 abalone/meter$^2$. In addition, fertilization success fell to below 50 percent as abalone densities fell below 0.15 abalone/meter$^2$ (Babcock and Keesing, 1999). Hobday and Tegner (2000) reported white abalone densities in California waters at less than 0.0002 abalone/meter$^2$ and it is estimated that the last successful white abalone recruitment in the wild most likely occurred during the 1970s (Davis et al., 1996; Hobday and Tegner, 2000). More recently, Butler et al. (2006) reported an overall density estimate of 0.0013 abalone/meter$^2$ with the highest densities reported off Tanner Bank at 0.00198 abalone/meter$^2$. While these more recent estimates appear to be higher than those reported by Hobday and Tegner (2000), they are still well below the threshold for successful fertilization as determined for other species of abalone.

Fertilization success also decreases with increasing distance between spawners because of dilution of sperm and the possibility of gametes not releasing at the same time (Pennington, 1985; Babcock and Keesing, 1999; Hobday et al., 2001). In addition to the low density estimates as mentioned above, Butler et al. (2006) also reported that a majority of individuals surveyed were greater than five meters apart along and between transects and that many were over 30 meters apart. According to studies conducted by Babcock and Keesing (1999), recruitment failure occurred in other species of abalone when males and females were greater than two meters apart from one another, suggesting that fertilization in white abalone may also be limited by linear distance between individuals.

The available literature on the age structure of the white abalone population indicate that the population is dominated by a few older animals at the end of their life span with a lack of new recruits entering the population (Davis et al., 1996; Davis et al., 1998; Hobday et al., 2001; Hobday and Tegner, 2000). Hobday and Tegner (2000) reported that the white abalone population densities were so low that even aggregation during spawning would not produce sperm and egg densities in sufficient quantities to allow for successful fertilization. While no surveys have specifically targeted new recruits (i.e. cryptic juveniles), the number of abalone growing old and dying out will need to be replaced by new generations of sexually mature adults in order for the wild population to

persist. Recent laboratory studies of white abalone, however, indicate that individuals as small as 25 millimeters are mature and are capable of spawning (McCormick and Brogan, 2003). Thus, the lack of survey information on new recruits (cryptic juveniles) makes it unclear whether the current population in the wild is capable of reestablishing itself. Variations in surveys and abundance estimates coupled with the lack of information on pre-emergent abundance makes it impossible to determine the future trend of the abalone population. In either case, for the purposes of this Opinion, we must assume that the white abalone population is suffering from recruitment failure and is currently declining towards extinction at an unknown rate.

In addition to density effects and persistent recruitment failure stemming from past commercial exploitation, white abalone also face a variety of other challenges shaping its current status. Predation is the principal source of natural mortality for all ages and life stages of abalone (Hooker and Morse, 1985) and a variety of predators exist throughout the course of their life history. Withering syndrome is a lethal bacterial disease which infects the digestive glands of abalone and has resulted in the mortality of greater than 90 percent of the black abalone population in many areas in California (Haaker et al., 1992; Leighton, 2000) while also posing a threat to other abalone species including the white abalone. Climate variability can affect abalone growth as warmer temperatures lead to decreased kelp growth (Tegner, 1989; Shepherd et al., 1998; Leet et al., 2001; Rodriguez-Valencia and Caballero-Algria, 2002) and increased threat of diseases such as withering syndrome (Moore et al., 2000). White abalone also face threats from habitat degradation in the form of land-based sources of pollution and impacts from offshore oil and gas structures. More details on these and other natural and anthropogenic threats to white abalone survival and recovery occurring in the action area may be found in the *Environmental Baseline* section of this Opinion.

## ENVIRONMENTAL BASELINE

By regulation, environmental baselines for biological opinions include the past and present impacts of all state, federal or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions that are contemporaneous with the consultation in process (50 CFR §402.02).

The purpose of the *Environmental Baseline* section is to step down from the species level discussion in the *Status of the Species* section and establish the current and projected viability or fitness of individuals and populations within the action area so that the effects of the proposed research activities can be measured and assessed. The following sections summarize the natural phenomena as well as the anthropogenic activities that have affected and continue to affect listed white abalone in the action area.

Natural Sources of Stress and Mortality

*Predation and Interspecific Competition*

White abalone face a variety of predators throughout the course of their life history in the action area. For example, filter-feeders will consume abalone at the egg and larval stages while predation by small crustaceans, sea stars, and protozoans is greatest during the post-larval stages (Leighton, 2000). Typical predators on juveniles and adults include cabezon, starfishes, octopuses, spiny lobsters, crabs, sheephead, moray eels, bat rays, and human poachers (O'Connell, 1955; Gotshall, 1977; Hobday and Tegner, 2000). White abalone are also important prey items of sea otters; however, the extent that sea otter predation has resulted in extirpation of the species is unknown. For example, in central California, several abalone species (red, flat, pinto and black) co-exist with sea otters (Lowry and Pearse, 1973; Cooper et al., 1977; Hines and Pearse, 1982; Rogers-Bennett, 2007). Nevertheless, sea otter predation may limit white abalone populations to small individuals that are restricted to cryptic habitats and, thus, are expected to represent a natural threat to the recovery of the species in the wild (Johnson et al., 2009).

While interspecific competition has not been studied extensively for white abalone, studies from other abalone species document significant competition with sea urchins for algal resources and physical crevice space (Strain and Johnson, 2009). Urchins attack attached kelps when drift becomes scarce and urchin populations are capable of destroying entire stands of kelp (Tegner, 1989; Hobday and Tegner, 2000). Also, past competition with pink abalone has been implicated in restricting the upper depth distribution of white abalone (Tutschulte, 1976). Densities of these co-inhabitants in areas where white abalone currently reside are low, and interactions with white abalone are thought to be minimal; however, increased abundance of sea urchins could lead to decreased prey as well as physical space similar to other species of abalone.

*Disease*

Withering syndrome is a fatal disease (Haaker et al., 1992) caused by the RLP bacterium that affects the digestive epithelium of abalone (Friedman et al., 2000). First detected in 1985, withering syndrome disease has significantly affected west coast abalone species, especially the black abalone and is thought to be endemic to central and southern California waters. While withering syndrome has not been observed in the past in wild white abalone (Friedman et al., 2000), this species is susceptible to the disease in captive settings based on information provided from the current research applicants. As part of their application for the current permit, the researchers indicated that a large number of captively-bred white abalone at the Channel Islands Marine Resource Institute (CIMRI) died in recent years (2002-2005) and showed symptoms of withering syndrome. Although disease was not considered a cause or a major contributing factor to the declines that led to the listing of white abalone, it is clear that disease (especially withering syndrome) is a threat to effectively recovering the species in the future due to the presence of the RLP bacterium in southern California waters (NMFS, 2008).

Another potential threat to captive and wild abalone populations is an exotic polychaete worm (*Terebrasabella heterouncinata*) that inhabits the shells of abalone where it lives in tubes. This sabellid worm was introduced into California abalone farms during the mid-

to late-1980's with imported South African abalone. The parasite causes shell deformities that weaken the shells of abalone, thereby reducing growth rates and production (Culver et al., 1997; Leighton, 2000). Since the introduction of this nonindigenous polychaete worm to aquaculture facilities, the state of California requires that any abalone to be planted in State waters must originate from a hatchery that has been certified as sabellid-free. The State conducts regular inspections of all aquaculture facilities to certify that they are, in fact, sabellid-free. Although these measures greatly reduce risks associated with the parasite, it remains remotely possible that wild white abalone have been exposed to this organism in the action area. However, the extent that sabellid worm infestation currently impacts wild white abalone populations is uncertain at this time.

*Climate Variability*

Long-term or short-term changes in ocean conditions, particularly as they relate to water temperature, could affect both larval and adult abalone (Hobday and Tegner, 2000), but neither direct nor indirect effects have been documented in the wild. Leighton (1972) examined the effect of water temperature on white abalone larval growth, settlement and survival and found that larval growth and survival were optimized between 14-18$^{o}$C, but that larvae were not successful at 10-12$^{o}$C. Short-term changes in ocean conditions due to El Niño events might raise sea surface temperatures (SSTs) above the optimum for larval growth and survival, and, due to cascading effects stemming from a decline in the *Macrocystis* canopy, could lead to poorer condition of adults (Tegner, 1989). The long-term warming trend in SST in the eastern Pacific Ocean (Hayward, 1997) may actually increase larval survival as SST approaches the optimum (14-18$^{o}$C) for larval survival in the laboratory; however, SST rise could have a negative effect on adults for the same reasons mentioned above.

Warmer water conditions associated with climate change and El Niño events may also be associated with decreased kelp growth (Tegner et al., 2001) as nutrient availability (e.g. nitrogen) is often inversely related to sea water temperature. Consequently, increased water temperature may deplete a major food source for adult white abalone (Tegner et al., 2001). Severe storms may also result in loss of standing stocks of kelp. Declines in growth or abundance of white abalone as a result of low food availability, however, have not been reported to date.

The influence of disease (i.e. withering syndrome) may increase during periods of warm water conditions as well (Moore et al., 2000). Although warm water does not initiate disease, warmer SST has been associated with increased mortality rates in abalone afflicted with withering syndrome (Lafferty and Kuris, 1993; Moore et al., 2000; Friedman et al., 2003). Laboratory studies have confirmed that temperature is important in transmission and development of clinical disease (Friedman et al., 1997a; Moore et al., 2000). For example, red abalone exposed to temperatures around 18° C develop clinical disease, while those held at around 15 °C remain healthy (Moore et al., 2000). The current researchers in their summary of previous research (unpublished data) included in their permit application indicated that white abalone reared at temperatures less than 12° C, while infected with the withering syndrome-bacterium, remained free of clinical disease while those reared at 15 or 18°C developed withering syndrome and had heavy

bacterial infections. These data combined with the magnitude of losses experienced by white abalone that were not treated with a therapeutant to reduce bacterial infections suggest that this species is highly susceptible to this pathogen under increasing warmer SST conditions.

Anthropogenic Sources of Stress and Mortality

*Historical Harvest*

White abalone abundance has declined significantly within the action area and throughout its range as a result of overutilization for commercial and recreational purposes. Hobday and Tegner (2000), as well as others (e.g. Estes and VanBlaricom, 1985), suggest that white abalone in California were subject to ‘‘serial depletion’’ by the commercial fishery during the early 1970s. Serial depletion occurs as fishermen shift from exploited to unexploited fishing areas due to local depletion. From 1965-1994 white abalone accounted for 284 of the 23,270 metric tons of abalone landed in California. Annual landings peaked in 1972 at 65 metric tons before declining and leveling off at 20 metric tons from 1972-1976 (Davis et al., 1998). Catch of white abalone was so rare by 1978 that the reporting requirement for numbers of white abalone landed was revoked. Abalone fisheries (commercial and recreational) for white, pink, and green abalone were closed in 1996 and remain closed throughout California.

Critically low densities caused by heavy exploitation throughout the 1970’s have led to poor recruitment success over a period of three decades in the action area as well throughout the white abalone’s historical range. Data collected by the National Park Service annually at the northern Channel Islands since the mid-1980's and from ROV/Submersible cruises conducted from 1980-1981, 1990-1991, 1996-1997, 1999, and 2002 (Davis et al., 1996; Davis et al., 1998; Hobday et al., 2001; Lafferty et al., 2004; Butler et al., 2006) suggest that recruitment has been negligible since the early 1970s. Therefore, white abalone continue to feel the effects of lower recruitment and reproductive potential as a result of historical commercial and/or recreational harvest.

*Illegal Poaching*

Illegal poaching is known to occur in California waters and has been suggested as a contributing factor to the continued decline of white abalone since the fishery officially closed in 1996 (NMFS, 2008). The California Department of Fish and Game estimates that approximately 4,800 abalone per day are taken illegally in northern California. However, the relative proportions of each species contributing to the total illegal harvest in southern California are not known. Poaching continues to be an issue at present and will continue to be a problem as long as a strong monetary incentive for poaching exists ($100 per white abalone [Davis et al., 1998]). Buyers of black market abalone include local restaurants and seafood markets as well as international businesses (Daniels and Floren, 1998). Future designation of Marine Protected Areas/Conservation Areas or the closure/restriction of other fisheries (rockfishes) that may overlap with white abalone habitat could help to reduce illegal take of white abalone in California through increased enforcement and public awareness (NMFS, 2008).

*Habitat Degradation*
A variety of pollutants enter the southern California waters from a range of sources that may degrade white abalone habitat in the action area. Runoff from land, waste water discharge from electrical power plants and water treatment plants can introduce a mix of organic and industrial pollutants into coastal waters. Ships and port terminals and illegal discharge of ballast water are other potential sources of pollution within the SCB. Natural oil seeps, or places where natural gases and liquid petroleum escape through fissures in the sea floor, occur in the Santa Barbara Channel and in the Santa Monica Bay areas of the SCB. Due to the isolation of the offshore islands of southern California and northern Baja California and the depth range of the species, anthropogenic impacts to white abalone habitat should be limited near the islands; however, pollution from mainland sources may contribute to habitat degradation for the species throughout its range.

Abalone are also known to bioaccumulate high levels of heavy metals in the presence of high environmental concentrations (Wang et al., 2009). Although toxicology of abalone is poorly known, red abalone have demonstrated metabolic breakdown when exposed to the pesticide 3-trifluoromethyl-4-nitrophenol (Viant et al., 2001). Silver, cadmium, and mercury are also known to bioaccumulate in abalone, likely from ingested algae (Huang et al., 2008). The effects of other heavy metal industrial pollution and the depths to which pollutants may have an impact on the wild white abalone population, however, are uncertain.

*Offshore Oil and Gas Installations*
As reported in LGL Ltd (2008), offshore oil and gas development has occurred in leased tracts in California waters from the mean high tide line to 3 miles offshore, and in federal waters from 3 to 11 miles offshore. Offshore oil platforms located within the SCB could potentially contribute to oil slicks as a result of unintentional leakage or spills. Oil particles can sink to the depths where abalone populations are found but oil's propensity to sink varies with density and sorption of particulates. Oil also can be transported from the surface deeper into the water column as zooplankton ingest and expel oil particles. The effect of oil pollution on the status of white abalone populations, however, is uncertain.

The Exxon Mobil Corporation previously applied for permits to replace a power cable running from shore (State waters) to an offshore oil and gas platform (Federal waters), to remove part of a failed cable, and to install a power cable between two platforms in federal waters in the Santa Barbara Channel. During pre-installation operations in 1999-2000, a single white abalone was discovered on one of the cables. This animal was not re-sighted during subsequent surveys. However, the possibility remains that stray individuals may be encountered during oil and gas activities. Given this, NMFS continues to consult with The Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE), formerly the Minerals Management Service, and is requiring biological surveys for subsequent projects occurring offshore.

*Scientific Research*
Under the current ESA permit (permit No. 1346-01), researchers established a cultivation and research effort in cooperation with federal and state agencies as well as colleges, universities, and aquariums. A portion of the activities involved collecting white abalone from the wild to be maintained and used for broodstock for captive propagation and research on the progeny produced. A previous Biological Opinion issued in 2004 for the prior permit evaluated the effects to the wild white abalone population and risks involved in removing reproductively capable adults from the wild to be maintained in the captive setting and to be used in experimental field planting similar to techniques currently proposed. The general population dynamics model approach used in the risk analysis for that Biological Opinion evaluated the short term risk of removing white abalone individuals from the wild with the benefits of successfully establishing new recruits to the population. The final determination in that previous Biological Opinion concluded that the research activities would not jeopardize the continued existence of white abalone.

Although the ultimate goal of the captive propagation program located at the previously utilized Channel Islands Marine Resource Institute (CIMRI) facility was to produce white abalone for field planting, a very large proportion of the progeny succumbed to withering syndrome and most of the remainder died of unknown causes or in association with a poorly understood disease of the shell. In May 2008, due to growing concerns about potential disruptions in high quality water supply, all of the white abalone at the previous facility (wild-collected broodstock, n=4, and their progeny, n=30) were transferred to the UC Davis Bodega Marine Laboratory in Bodega Bay, California. Due to disease concerns, no progeny produced and maintained under the previous permit were outplanted in the field over the duration of the permit. However, researchers identified an effective antibiotic treatment capable of completely eliminating the pathogen from infected individuals, thereby reducing the risk of further catastrophic mortality and/or disease outbreaks under the current research actions as proposed. Nevertheless, the fact that researchers were not able to conduct successful outplanting under the previous permit suggest that the wild white abalone stock may have suffered from reduced recruitment compared to that which would have occurred had the collected broodstock not been removed from the wild; however the extent of this impact is currently unknown. For the purposes of this consultation, however, we will assume that the wild population in the action area is currently affected by this reduced recruitment potential since no successful outplanting occurred over the duration of the previous permit. No other current research permits are authorized for research on wild white abalone at the time of this consultation.

*Conservation and Management Efforts*
Regulatory measures have been taken by the state of California during the past 30 years to help curtail the decimation of the wild white abalone population, including the closure of the white abalone fishery in 1996, and the closure of all abalone fisheries in central and southern California in 1997. Since the early 1990s, progress has been made on several fronts to learn more about the biology of white abalone in California and to develop a recovery strategy for the species. The state of California, federal agencies, academic institutions, non-governmental organizations and others have conducted or

participated in efforts to determine which factors contributed to white abalone's decline, determine its current status, and discuss measures that should be taken to recover the species. In addition, a comprehensive recovery plan was developed by the white abalone recovery team and finalized in 2008. The White Abalone Recovery Plan focused on addressing threats across the species' entire range determining and prioritizing the actions that should be taken to recover and conserve the species, and to state what criteria should be used to gauge when and if the species can be downlisted and eventually removed from the list. It is expected that current and ongoing conservation and management efforts should contribute to a beneficial impact on wild white abalone populations in future years.

## EFFECTS OF THE PROPOSED ACTION

Pursuant to Section 7(a)(2) of the ESA, federal agencies are directed to insure that their activities are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. In this section, we describe the potential physical, chemical, or biotic stressors associated with the proposed action, the probability of individuals of listed species being exposed to these stressors, and the probable responses of those individuals (given probable exposures) based on the best scientific and commercial evidence available. As described in the *Approach to the Assessment* section, for any responses that would be expected to reduce an individual's fitness (i.e., growth, survival, annual reproductive success, and lifetime reproductive success), the assessment would consider the risk posed to the viability of the population(s) those individuals comprise and to the listed species those populations represent. The purpose of this assessment is to determine if it is reasonable to expect the proposed research activities to have effects on listed species that could appreciably reduce their likelihood of surviving and recovering in the wild.

This Opinion assesses the effects of the proposed propagation, maintenance, and research activities to be conducted on previously collected wild broodstock and captive-bred progeny and the subsequent reintroduction of progeny into the wild through experimental outplanting techniques. The Endangered Species Division is particularly concerned with potential effects of introducing captively bred progeny into the wild and the potential indirect effects this may have to the wild population through potential disease transmission, competition for resources, and increased predation.

### Exposure Analysis

Exposure analyses identify the co-occurrence of ESA-listed species with the action's effects in space and time, and identify the nature of that co-occurrence. The exposure analysis identifies, as possible, the number, age or life stage, and gender of the individuals likely to be exposed to the action's effects and the population(s) or subpopulation(s) those individuals represent.

This Opinion distinguishes between the captive population of white abalone currently held at the research facilities to be utilized under the proposed permit and the wild population of white abalone currently inhabiting waters in southern California. All

research activities, as proposed, would result in exposure of captive white abalone to captive propagation, grow-out and maintenance, public display, and various captive experiments on reproduction, disease, and larval biology. In addition, some captive progeny will be exposed to experimental field planting at three established sites off the southern coast of Santa Cruz Island in the Channel Islands region. Researchers plan to outplant captive progeny in areas that once supported wild white abalone individuals but do not currently contain any members of the wild population. Researchers plan to make every effort to avoid outplanting in areas containing wild white abalone thereby reducing the probability of exposure of members of the wild population to the direct effects of the proposed action.

Over time, however, the goal of the researchers is to eventually produce viable numbers of recruits that can assimilate into and expand the wild population. Therefore, when analyzing exposure to the effects of the proposed action, our first level of exposure assesses members of the captive population that will be exposed to the effects of the captive research and experimental outplanting procedures. The second part of our exposure analysis assesses the exposure of the wild population to direct and (most likely) indirect effects of introducing captively bred progeny into the marine environment over the course of the permit.

*Exposure of Captive White Abalone*

The proposed research will expose captive white abalone to captive propagation, grow-out and maintenance, public display at three separate aquaria, and experimental field planting at three established sites on the southern coast of Santa Cruz Island in the Channel Islands region. In the *Description of the Proposed Action* section of this Opinion, **tables 2-10** display the expected take numbers that were provided to the Endangered Species Division during the consultation period. As indicated in the aforementioned tables, NMFS-NWFSC and Scripps Institution of Oceanography will only receive frozen tissue samples for genetics analyses. Since these activities will not result in the use of live individuals, those facilities will not expose abalone to any potentially adverse effects and are not included in our analysis. Similarly, the transport of dead animals and associated materials between the various facilities will also not result in any effect to live white abalone and will also not be included in our exposure analysis.

The following tables provide the expected exposure of white abalone life stages to captive grow-out, maintenance, research, public display, and experimental field planting procedures at each facility. Many of the proposed activities to be conducted in captivity represent activities that have been permitted for in the past and will continue under the current permit. The numbers account for possible increases in abundance of white abalone in the captive setting assuming successful captive propagation and avoidance of catastrophic disease outbreaks affecting the broodstock and progeny at each facility. The numbers also account for estimates of the maximum mortality and survival of white abalone expected in the field due to experimental field planting (see sections below for further justification). The researcher's application that accompanied the Environmental Assessment did not require additional individuals to be collected from the wild and base their numbers on research needs and the maximum possible research effort that could

occur in the captive setting given the space constraints of the facilities to be utilized. Given that, the Endangered Species Division assessed the exposure of captive white abalone at the levels proposed by Permits Division.

**Table 11: Annual Exposure of White Abalone to Public Display at Aquaria**

| FACILITY | ORIGIN OF WHITE ABALONE | LIFESTAGE | NUMBER OF ANIMALS PER YEAR | Notes |
|---|---|---|---|---|
| Aquarium of the Pacific | Captive | All | 200 | Dead/live animals may be transported to other facilities as needed; Take includes captive maintenance and unintentional mortality while in captivity |
| Cabrillo Marine Aquarium | Captive | All | 200 | |
| Ty Warner Sea Center | Captive | All | 200 | |

**Table 12: Annual Exposure of White Abalone to Laboratory Experiments in Reproduction, Larval Biology, and Disease Pathology (including terminal research)**

| FACILITY | ORIGIN OF WHITE ABALONE | LIFESTAGE | NUMBER OF ANIMALS PER YEAR | Notes |
|---|---|---|---|---|
| UC Davis Bodega Marine Laboratory | Captive | Adult/Juvenile | 6500 | Take includes captive maintenance and unintentional mortality while in captivity and as a result of lab experiments. Take also includes transfer to and from other grow-out facilities as needed. |
| | Captive | Juvenile | 30000 | |

| **Table 12: Annual Exposure of White Abalone to Laboratory Experiments in Reproduction, Larval Biology, and Disease Pathology (including terminal research)** ***continued*** | | | | |
|---|---|---|---|---|
| **FACILITY** | **ORIGIN OF WHITE ABALONE** | **LIFESTAGE** | **NUMBER OF ANIMALS PER YEAR** | **Notes** |
| UC Davis Bodega Marine Laboratory | Captive | Larvae | 2 million | Take includes captive maintenance and unintentional mortality while in captivity and as a result of lab experiments. Take also includes transfer to and from other grow-out facilities as needed. |
| | Captive | Egg | 5 million | |
| UC Santa Barbara Marine Science Institute | Captive | Adult | 2000 | Take includes captive maintenance and unintentional mortality while in captivity and as a result of lab experiments. Take also includes transfer to and from other grow-out facilities as needed. |
| | Captive | Juvenile | 2000 | |
| | Captive | Larvae | 5 million | |
| | Captive | Egg | 5 million | |
| NMFS-SWFSC | Captive | Adult/Juvenile | 2000 | Take includes captive maintenance and unintentional mortality while in captivity and as a result of lab experiments. Take also includes transfer to and from other grow-out facilities as needed. |
| | Captive | Larvae | 50000 | |

| **Table 12: Annual Exposure of White Abalone to Laboratory Experiments in Reproduction, Larval Biology, and Disease Pathology (including terminal research) *continued*** | | | | |
|---|---|---|---|---|
| **FACILITY** | **ORIGIN OF WHITE ABALONE** | **LIFESTAGE** | **NUMBER OF ANIMALS PER YEAR** | **Notes** |
| University of Washington School of Aquatic and Fisheries Science | Captive | All | 500 | Take includes captive maintenance and will likely result in mortality of all individuals exposed due to terminal disease research |

| **Table 13: Annual Exposure of White Abalone to Captive Maintenance[4], Grow-Out, and Propagation (Spawning/Breeding)** | | | | |
|---|---|---|---|---|
| **FACILITY** | **ORIGIN OF WHITE ABALONE** | **LIFESTAGE** | **NUMBER OF ANIMALS PER YEAR** | **Notes** |
| UC Davis Bodega Marine Laboratory | Wild (currently maintained in captivity) | Adult | 3 | Take includes captive spawning and maintenance and unintentional mortality while in captivity. Take also includes transfer to and from other grow-out facilities as needed. |
| | Captive | Adult | 100000 | |
| | Captive | Larvae | 25 million | Take includes captive maintenance and unintentional mortality while in captivity. Take includes transfer to and from other grow-out facilities as needed |
| | Captive | Egg | 40 million | |

4 Captive maintenance includes procedures to carry out measuring, tagging, genetic sampling, weighing, inoculation against disease, health and gonad examination, breeding, and treatment for wounds as described in the application.

| Table 13: Annual Exposure of White Abalone to Captive Maintenance[5], Grow-Out, and Propagation (Spawning/Breeding) *continued* | | | | |
|---|---|---|---|---|
| **FACILITY** | **ORIGIN OF WHITE ABALONE** | **LIFESTAGE** | **NUMBER OF ANIMALS PER YEAR** | **Notes** |
| UC Santa Barbara Marine Science Institute | Captive | Adult | 10000 | Take includes captive spawning and maintenance and unintentional mortality while in captivity. Take also includes transfer to and from other grow-out facilities as needed |
| | Captive | Juvenile | 10000 | Take includes captive maintenance and unintentional mortality while in captivity. Take also includes transfer to and from other grow-out facilities as needed. |
| | Captive | Larvae | 20 million | |
| | Captive | Egg | 20 million | |
| Cabrillo Marine Aquarium | Captive | Adult | 100 | Take includes captive spawning and maintenance and unintentional mortality while in captivity. Take also includes transfer to and from other grow-out facilities as needed. |

5 Captive maintenance includes procedures to carry out measuring, tagging, genetic sampling, weighing, inoculation against disease, health and gonad examination, breeding, and treatment for wounds as described in the application.

| Table 13: Annual Exposure of White Abalone to Captive Maintenance[6], Grow-Out, and Propagation (Spawning/Breeding) *continued* | | | | |
|---|---|---|---|---|
| **FACILITY** | **ORIGIN OF WHITE ABALONE** | **LIFESTAGE** | **NUMBER OF ANIMALS PER YEAR** | **Notes** |
| Cabrillo Marine Aquarium | Captive | Juvenile | 10000 | Take includes captive maintenance and unintentional mortality while in captivity. Take also includes transfer to and from other grow-out facilities as needed. |
| | Captive | Larvae | 10 million | |
| | Captive | Egg | 10 million | |
| Aquarium of the Pacific | Captive | Adult | 1000 | Take includes captive spawning and maintenance and unintentional mortality while in captivity. Take also includes transfer to and from other grow-out facilities as needed |
| | Captive | Juvenile | 10000 | Take includes captive maintenance and unintentional mortality while in captivity. Take also includes transfer to and from other grow-out facilities as needed. |
| | Captive | Larvae | 20 million | |
| | Captive | Egg | 20 million | |

6 Captive maintenance includes procedures to carry out measuring, tagging, genetic sampling, weighing, inoculation against disease, health and gonad examination, breeding, and treatment for wounds as described in the application.

| Table 14: Annual Exposure of White Abalone to Experimental Field Planting | | | | |
|---|---|---|---|---|
| **FACILITY** | **ORIGIN OF WHITE ABALONE** | **LIFESTAGE** | **NUMBER OF ANIMALS PER YEAR** | **Notes** |
| UC Davis Bodega Marine Laboratory | Captive | Adult | 50000 | Take includes transport to field sites, observation and monitoring, and unintentional mortality in the field |
| | Captive | Juvenile | 100000 | |
| | Captive | Larvae | 2 million | |

To summarize the information above, annual exposure as a result of public display would be 600 individuals at various life stages across the three public aquaria. Annual exposure for laboratory research activities across all facilities would be 10,500 adults, 32,000 juvenile, 12,000,000 larvae, and 10,000,000 eggs with exposure of 500 additional individuals at various life stages to terminal disease research at the University of Washington. All research activities will be performed on progeny and will not include testing of broodstock that were previously collected from the wild. Annual exposure for captive maintenance, propagation, and grow-out across all facilities would be 111,103 adults, 30,000 juveniles, 75,000,000 larvae, and 90,000,000 eggs. Finally, annual exposure for field planting activities conducted by UC Davis Bodega Marine Lab would be 50,000 adults, 100,000 juveniles, and 2,000,000 larvae.

Based on the researcher's experience, each female abalone that is induced to spawn will produce about 5,000,000 eggs most of which (95-100 percent) will achieve successful fertilization. Typically 50 percent of fertilized eggs (or 25,000,000) will not hatch successfully. During the one week larval stage, mortality is usually two to five percent while mortality increases to 95-98 percent during the six month transition from swimming larvae to juveniles. Mortality during the next six months averages 30 percent while mortality during grow-out to the adult stage may be an additional five to ten percent per year. To put these numbers in context, one female that successfully spawns may produce 25,000,000 fertilized eggs with only 500,000 to 1,000,000 of those successfully reaching the larval-juvenile stage and only 10,000 to 20,000 of those successfully reaching the adult stage. The routine mortalities that will occur at every life stage in large-scale abalone cultivation is reflected in the numbers above and represent the maximum take expected over the life of the permit. Researchers intend to raise at

least 5,000 progeny to maturity from each year class for annual field planting activities with the excess progeny utilized for research and additional grow-out.

*Exposure of Wild White Abalone*

The possibility exists that an unidentified number of wild white abalone could be exposed to effects from field planted abalone at the established outplant sites off Santa Cruz Island. NMFS evaluated possible exposure of wild animals to disease/parasites that went undetected in the laboratory prior to field planting or were indirectly transmitted through other species of abalone located in the vicinity of the BARMs. The BARMs to be used for field planting are located in areas which were once productive for wild white abalone during the fishery (Rogers-Bennett et al., 2002) but currently do not contain wild individuals. The BARMs are also located in shallower depths (18-26 meters) than depths that typically contain the highest densities of wild abalone (40-50 meters) based on recent surveys (Butler et al., 2006). These BARMs have been monitored under a previously issued permit since they were deployed in 2004 and researchers intend to review survey data prior to deployment. Monitoring of the outplant sites before and after deployment of abalone will help identify if any other abalone species are located in the vicinity of the BARMs.

Wild white abalone are not expected to be encountered based on the prior survey data and the fact that BARMs are located in shallower areas than is known to currently support members of the wild population; however, in the event that wild white abalone are found, researchers will avoid use of those BARMs and will cease outplanting activities at those sites. In the event that other non-listed species of abalone are encountered, researchers intend to remove them in a safe and efficient manner to prevent unintentional disease transmission to the field planted progeny. Researchers will also screen captive progeny targeted for field planting before introducing them into the wild. Therefore, given these mitigation measures and given the experience of the researchers at identifying appropriate disease symptoms, the Endangered Species Division believes it is highly unlikely that wild white abalone will be directly exposed to these effects and these effects will not be evaluated further in this Opinion.

Indirect ecological effects of outplanting captive bred individuals include possible increases in predation and reduction in space and prey resources within the action area. While these effects would not result in the direct exposure of wild white abalone individuals, they are expected to expose suitable but currently unoccupied habitat available to the wild population and are therefore evaluated further in this Opinion. To evaluate this exposure, we will not use numbers of wild white abalone but will instead evaluate the spatial footprint of the BARMs to be used for field planting. Using this approach, up to 12 already deployed BARMs will be utilized that each have a spatial footprint of about eight square meters (based on 28.5 X 36 inch cage), making the total footprint 96 square meters. This means that 96 square meters of suitable but currently unoccupied habitat will be exposed to these indirect effects. We then evaluated the possible habitat responses expected from this exposure as well as any subsequent risks these responses would pose to the wild white abalone population.

Response Analysis

As discussed in the *Approach to the Assessment* section of this Opinion, response analyses determine how listed resources are likely to respond after being exposed to an action's effects on the environment or directly on listed animals themselves. For the purposes of consultation, our assessments try to detect potential lethal, sub-lethal, physiological or behavioral responses that could reasonably be expected to reduce a species' reproduction, numbers, or distribution (for example, by changing birth, death, immigration, or emigration rates; increasing the age at which individuals reach sexual maturity; decreasing the age at which individuals stop reproducing; among others). Ideally, response analyses would consider and weigh evidence of adverse consequences as well as evidence suggesting the absence of such consequences.

*Responses to Captive Maintenance, Grow-out, Propagation, and Public Display*

Researchers intend to spawn white abalone using UV irradiated water, hydrogen peroxide and/or thermal shock. These methods are already in use and have proven successful in the past (Hooker and Morse, 1985; McCormick, 2000). UV irradiated water and hydrogen peroxide induce spawning by activating the production of the natural spawning triggers (Morse and Morse, 1988). Thermal shock is then used in concert with UV irradiated water and hydrogen peroxide to increase the likelihood of a successful spawning event. The timing of these activities is crucial as chemicals used for the hydrogen peroxide method to activate spawning triggers in broodstock will kill gametes if spawning does not occur in fresh seawater. Also, the thermal shock method if done improperly could result in no release of gametes or the release of a large proportion of immature and deformed gametes (Hooker and Morse, 1985; Leighton, 2000). However, all facilities to be utilized for captive spawning (i.e. UC Davis Bodega Marine Laboratory, UC Santa Barbara Marine Laboratory, Cabrillo Aquarium, and Aquarium of the Pacific) will have adequate seawater delivery systems and trained personnel to perform spawning to maximize success of the captive propagation program. Genetic diversity will be maximized by conducting pair-wise mating of males and females. In addition, larvae, juveniles, and adults from each family will be cultivated separately, or marked to protect genetic integrity.

Water quality is the primary issue in the propagation and grow-out of abalone in the captive setting (Butler and Hunter, 2002). Fertilization, as well as survival of larvae to the settlement stage, can be 95-100 percent successful under proper water conditions (Leighton, 1985). Most larval mortality and developmental problems occur as a result of microbial growth in larval cultures which interferes with the normal settlement processes (Hooker and Morse, 1985). Additional mortalities can occur during the dietary transition from diatoms to macroalgae and in the grow-out tanks due to stress from handling, genetic or oogenic deficiency, different individual feeding rates, and assimilation of food and competition for food as is seen in other species of abalone (Ebert and Houk, 1984; Leighton, 1985). Survival is high for early juveniles but some abalone will succumb to dessication if they are allowed to crawl out of the tanks in addition to suffering stress and a depressed ability to feed (Leighton, 1985). Abalone are also highly sensitive to elevated levels of ammonia which could result in death, reduced growth rates, or higher respiration under poor water quality conditions (Hindrum et al., 2001; Harris et al., 1998).

However, the seawater delivery systems to be employed by the researchers under the proposed permit will maintain the temperature, supply oxygen, and remove waste in order to maximize growth and survival of captive abalone to the adult stage. Water circulation due to supplemental aeration will also help to maintain a constant temperature, move food toward abalone, and remove waste products.

Food and stocking densities all affect growth rates as well (McCormick, 2000; Clarke and Creese, 1998; Hooker and Morse, 1985). Higher stocking densities result in decreased growth despite ample amounts of food (Clarke and Creese, 1998). As more abalone are cultivated over the life of the permit, the high stock densities at each facility may result in slower growing abalone which are then more likely to be susceptible to trauma and stress from captive maintenance or other research activities (Hooker and Morse, 1985). Stress in abalone may also be linked to increased disease outbreaks and mortality by altering immune functions (Malham et al., 2003). For example, the green ormer (*Haliotis turberculata*) was subjected to mechanical disturbance designed to simulate handling and sorting in mariculture facilities. Stress, as measured by release of neuroendocrine messengers, initially increased but returned to normal values within 15-30 minutes. The production of these messengers, however, divert energy from functions such as growth, reproduction and immune functions thereby potentially reducing the fitness of abalone individuals living under these conditions (Malham et al., 2003).

Disease outbreaks are also a concern in the captive setting, especially the possible spread of withering syndrome and/or sabellid worm infestation. A very large proportion of the progeny cultivated under the previous permit succumbed to withering syndrome and most of the remainder died of unknown causes. In May 2008, due to growing concerns about potential disruptions in high quality water supply, all of the white abalone at the previous facility were transferred to the UC Davis Bodega Marine Laboratory to prevent further loss of broodstock and subsequent progeny. The RLP bacteria that causes withering syndrome invades the digestive cells, disrupting the ability of the abalone to assimilate food (Friedman et al., 1997b), resulting in pedal atrophy and a diminished ability to maintain a grip on rocky substrata (Lafferty and Kuris, 1993). Epipodial and mantle discoloration and a lack of response to tactile stimulation have also been observed in affected individuals (Haaker et al., 1992; Richards and Davis, 1993). After being exposed to the pathogen, it may take as long as eight months for symptoms to develop; however, once symptoms do arise, the animals succumb to death rapidly (i.e. within six weeks of developing symptoms) (Friedman et al., 1997b; Friedman et al., 2000; Friedman et al., 2002). While the possibility exists for disease transmission, researchers under the proposed permit have identified an effective antibiotic treatment capable of completely eliminating the pathogen from infected individuals, thereby reducing the risk of further catastrophic mortality and/or disease outbreaks under the current research as proposed.

The sabellid worm parasite is another concern for captive abalone species. This parasite causes shell deformities that weaken the shells of abalone, thereby reducing growth rates and production (Culver et al., 1997; Leighton, 2000). Since the introduction of this nonindigenous polychaete worm to aquaculture facilities, the state of California requires that any abalone to be planted in State waters must originate from a hatchery that has

been certified as sabellid-free and the facilities to be utilized for the proposed research are either already certified or in the process of obtaining certification at the time of this consultation.

Shell waxing will occur for adult breeders whose shells are more than 50 percent infested with encrusting organisms which weaken the shell and causes irritation while the abalone attempts to repair the inside of the shell. There is some stress associated with this procedure since abalone will be removed from tanks, handled and hot wax applied to the shell. Shell waxing is expected to induce temporary stress, but is not expected to kill or cause long term harm to animals treated with this procedure.

In summary, captive abalone exposed to spawning, captive maintenance, and public display are expected to suffer mortalities at all life stages due to typical life stage events as well as possible disease outbreaks and improper timing of spawning methods. Individuals that survive to the juvenile and adult stages may undergo short term stress associated with shell waxing as well as treatments for infection. At later stages of the permit term, higher stocking densities may result in decreased growth rates as well as a higher susceptibility to stress, trauma, and disease.

*Responses to Captive Research Activities*

Captive progeny undergoing research experiments in the subjects of disease pathology are expected to be killed due to exposure to pathogens or to prevent unintended outbreaks in other holding tanks or facilities. In addition larvae, juveniles, and adults are expected to be killed during other controlled research experiments conducted for studies on reproduction and/or larval biology, to protect the genetic integrity of the progeny, or to reduce the effects of overcrowding. Researchers will each raise at least 5,000 progeny to maturity from each year class for annual field planting activities while the additional progeny will be available for captive research experiments as proposed.

For research on genetics, a non-lethal tissue sampling methodology will be utilized that cuts a 1-2 sample from the epipodal tentacle from chosen abalone individuals. While short term stress is expected to individuals undergoing this procedure, researchers do not expect any long term harm and no fatal infection has been documented in the past as a result of this procedure.

In addition to mortality, abalone undergoing research experiments would be expected to undergo multiple levels of stress and/or trauma over the life of the permit due to exposure to handling by researchers and exposure to variables such as changes in temperature, salinity, etc. Researchers intend to minimize injury and overall mortality from controlled research activities through use of use of emergency systems to maintain water circulation in the event that primary systems break down, by using multiple facilities to prevent total losses in the event of a catastrophic event or to minimize overcrowding, by using sterile utensils and experienced personnel for tissue sampling, and minimizing handling time. Nevertheless, it is expected that abalone at all life stages exposed to research activities should experience mortality through the duration of the permit, especially for individuals chosen for disease pathology experiments.

*Responses of Captive White Abalone to Experimental Field Planting*
A large portion of animals (a minimum of 5,000) generated through captive propagation will be destined for field planting each year. As many as 50,000 adults, 100,000 juveniles, and 2,000,000 larvae could be planted in the field per year over duration of the permit. Overall, enhancement programs worldwide have met with mixed success (Burton and Tegner, 2000; McCormick, 2000; Tegner, 2000). While field planting studies have not been conducted for white abalone, the responses of similar species suggests juvenile survival rates range from as high as 80 percent to as low as one percent in the field (Rogers-Bennett and Pearse, 1998). Several studies on the Palos Verdes Peninsula in Los Angeles County with red abalone rendered a survival rate estimate of one percent for the first year for field planted individuals ranging in size from 20-80 millimeters in length (Tegner, 2000). In this case, the larger sizes appeared to have no effect on survival rates. Other studies done on Santa Cruz and Santa Catalina Islands involving field planted red and green abalone resulted in a survival estimate of 2.8 percent for the first and second year (Tegner, 2000).

Mortality of field planted abalone is variable and is affected by condition of abalone at release, size at planting, planting method, habitat type, food availability, and predation (McCormick et al., 1994; Sweijd, et al., 1998). Abalone can be stressed due to transport to field sites resulting in lower survival rates once planted in the field (Schiel, 1993). Higher predation pressures result when abalone are stressed since they secret a mucus which is detectable by predators. Once planted, physical and/or biotic elements of the bottom habitat may also conspire to preclude successful settlement and metamorphosis of planktonic larvae. Juvenile survival may be restricted by inadequate crevice shelter, open foraging area, and general predation. Certain ophiuroid and other filter-feeding species may capture field planted larvae, while sea stars, amphipods, other benthic predators may seek out recently settled postlarvae or larger juveniles. BARMs will be used to help establish substrate for juveniles being stocked into the wild and to aid in surveys to recover these juveniles to quantify growth and survival. These planting modules provide abalone with shelter until they recover and/or acclimate from transport to the field planting site and have been indicated in reducing mortalities due to stress and predation (Sweijd et al., 1998; Leighton, 1985; Leighton, 2000).

Potential behavioral modifications of hatchery raised white abalone may result in depressed survival rates of animals once field planted as individuals may not illicit the appropriate response when faced with a predator or potential competitor. Research to assess the behavior responses of hatchery reared white abalone to predator or competitor cues will be conducted to minimize these effects by “pre-conditioning” hatchery reared animals to predators and competitors prior to field planting. A study conducted by Delgado et al. (2002) with Florida queen conch (*Strombus gigas*) suggests that hatchery reared animals exposed to predators exhibit behaviors and morphologies that may render them better able to survive in the wild than their naïve counterparts. Briefly, survival rates of hatchery-reared white abalone would be compared to others once field planting occurs and if survival rates of these animals were significantly higher than wild animals, all animals destined for field planting would be exposed to predators and competitors on

a regular basis. If survival rates were the same or significantly lower, predator/ competitor exposure protocols would cease.

Hybridization of field planted progeny with other abalone species may increase upon field planting. Leighton and Lewis (1982) determined that the success of hybrid crosses in the laboratory, in terms of successful fertilization, varied between species, but that red and white abalone crosses experienced a 96 percent fertilization rate while crosses between other abalone species averaged a 10-36 percent fertilization rate. However, the same researchers reported that the formation of hybrids required a ten-fold increase in sperm and egg densities to achieve the same fertilization success rates as those of the same species (Leighton and Lewis, 1982). The expected densities of field planting trials along with the fact that researchers intend to plant in areas devoid of other abalone species lowers the risk of hybridization with other abalone species.

*Indirect Habitat Responses from Experimental Field Planting*
The field planting trials will also expose 96 square meters of suitable but currently unoccupied habitat that would otherwise be available for the wild population of white abalone. The total amount of suitable white abalone habitat currently available to the wild population off southern California is not well known as the bathymetry and substrate characteristics through much of the species' range have not been adequately mapped. Past estimates of the amount of available habitat have been based on the assumption that three percent of the sea floor is rocky substrate (Thompson et al., 1993). Davis et al. (1998) estimated the area of rocky reef habitat at 25-65 meter depths within the historic range of the species to total 966 hectares (9,660,00 square meters) with 752 hectares (7,520,000 square meters) occurring within southern California. However, a more recent survey by Butler et al. (2006) found that over 3,000 hectares (over 30,000,000 square meters) of rocky substrate between 30-60 meter depths existed in a limited area off the southern California coast, suggesting that more suitable habitat exists than was previously thought. Therefore, given the best available estimates of suitable substrate available to the wild population off southern California, the amount of space expected to be utilized by field planted abalone over the life of the permit is unlikely to result in a measurable impact in terms of habitat availability for the wild population and therefore these effects are discountable.

Field planting may result in a reduction in prey resources available to wild white abalone in the action area through direct consumption by field planted progeny. However, a lack of prey resources was not a major factor in the decline of the wild population and no evidence suggests that prey resources are currently limited in the action area (Hobday and Tegner, 2000). Thus, given the extremely low numbers of the wild population and the fact that prey resources are not considered to be a major factor limiting their recovery, the return of white abalone to former densities through field planting is unlikely to have a measurable impact on prey resources available within the action area and these effects are therefore discountable.

Field planted abalone will attract predators to these areas which may spill over into nearby habitats where wild white abalone reside, thus indirectly increasing predation of

the wild population. The rate of predation would depend on the habitat and abundance of predators which prey on particular life stages of abalone. Interactions with one of abalone's primary predators, the threatened southern sea otter (*Enhydra lutris nereis*), would be kept at a minimum by choosing field planting areas that are beyond the current range of the sea otter and field planting would be coordinated with the southern sea otter recovery team as recommended by the U.S. Fish and Wildlife Service. Otter abundance and foraging habits would become an important consideration as abalone abundance increases and sea otters expand their range. Other observed predators include asteroids (*Pyncnopodia*, and *Astrometis*), fish (*Scopaenichthys*, *Myliobatis*, and *Semicossyphus*), crustaceans (*Panulirus*, *Cancer*, and *Loxorhynchus*), and octopuses (*Octopus* spp.) (Hobday and Tegner, 2000). How the abundance and density of these potential predators may change once the field planting program begins remains unknown, but removal (or absence) of potential predators is proposed during the initial field planting experiments which is expected to help minimize the impact of predation within the action area.

Since the numbers of white abalone are expected to increase as a result of this captive propagation and outplanting program, the risk of poaching is also expected to increase within the action area. Poaching of white abalone will continue to pose a threat to the success of field planting activities as well as the current wild population over the duration of the permit. Marine Protected Areas (MPAs) at the Channel Islands National Marine Sanctuary, recently established by California's Fish and Game Commission, may offer some protection from poachers both because the use of these areas by commercial and recreational fisherman is prohibited and because the enforcement presence within MPAs will continue to grow. While the effect of MPA protection on the wild white abalone population is unknown given the species' extremely low numbers, these measures are expected to at least minimize the impact of poaching for both the field planted abalone as well as the wild population in the action area over the duration of the permit.

Risk Analysis

Our risk analyses reflect relationships between listed species, the populations that comprise that species, and the individuals that comprise those populations. Our risk analyses begin by identifying the probable risks actions pose to listed individuals that are likely to be exposed to an action's effects. Our analyses then integrate those individual risks to identify consequences to the populations those individuals represent. Our analyses conclude by determining the consequences of those population-level risks to the species those populations comprise.

White abalone are suffering from recruitment failure and individuals observed in the wild are currently not in sufficient densities or are too far apart to support successful fertilization at levels measured for other abalone species (Babcock and Keesing, 1999; Butler et al., 2006). If the remaining white abalone are reproductively isolated, the number of individuals that die or emigrate from the population will over time exceed the number born or immigrating into the population and, thus, the population will decline to extinction.

The proposed permits would continue a captive propagation and field planting program where captive-bred white abalone that are capable of reproduction will be field planted to supply recruits in an effort to reverse the decline of the wild white abalone population. Additional cultivated progeny will be used for research purposes to provide data and information on white abalone genetics, reproduction, larval biology, and disease pathology. It is expected that captive white abalone will experience mortality at every life stage in order to achieve these objectives. For those that do not die over the duration of the permit, many will experience varying degrees of stress and trauma as a result of captive maintenance and handling, research experiments, and during transit to and from research and grow-out facilities as well as field plant sites. Over time as the captive population expands and densities in the captive setting increase, captive individuals may experience decreased growth rates and a lower suppression for disease as has been measured for other species under high density conditions (Clarke and Creese, 1998). There is also the threat of disease outbreaks (e.g. withering syndrome) and/or parasite infections (e.g. sabellid worm infestation) that have already caused catastrophic losses of individuals under the previous permit.

As previously discussed, mitigation measures have been developed to address the above concerns. The use of UV irradiated seawater delivery systems with emergency systems will help maintain adequate water quality conditions for the captive population and will provide optimal conditions for growth and survival throughout their life history stages while in the captive setting. In addition, captive individuals will be visually examined daily to monitor their health status and researchers will make sure that adequate aeration and water flow are provided at all times. Immediate alert systems have been established to immediately notify appropriate parties in response to a facility malfunction and the use of multiple facilities for both grow-out and captive propagation should help minimize the total loss of white abalone individuals should a catastrophic system failure or undetected disease outbreak occur. Researchers have developed an antibiotic treatment for the control of the RLP that causes withering syndrome and will treat affected animals with OTC treatments consistent with protocols established in the *NMFS White Abalone Disease and Parasite Management Plan* included in the final recovery plan for the species (NMFS, 2008). Also, all facilities to be utilized for captive propagation are either certified as sabellid-free or are in the process of obtaining certification and will undergo routine inspections over the duration of the permit to minimize the threats posed by this parasite. These measures should reduce the risk of captive-bred animals becoming infected with disease or parasites, increase the reproductive potential of field planted animals, and reduce the risks of introducing disease and parasites into the wild during field planting trials. Therefore, while adverse fitness consequences are likely to occur to individual abalone in the form of mortality and stress associated with the captive propagation and research program, long term threats to the entire captive population are unlikely and are not expected to result in adverse consequences for the wild population or the species as a whole.

The researchers' goal for the experimental field planting program is to maintain at least 5,000 captive white abalone each year to be field planted at predetermined sites with the intent to eventually establish successfully reproducing colonies. Higher numbers of

abalone may be field planted depending on the success of the captive propagation program with a maximum of 50,000 adults, 100,000 juveniles, and 2,000,000 larvae authorized to be field planted in a given year. Given the mixed results seen in other species, the success of a captive propagation and field planting program for white abalone is uncertain (Burton and Tegner, 2000; McCormick, 2000; Tegner, 2000). Preliminary data, however, suggest that the captive propagation could produce progeny that reach reproductive maturity faster than expected in the wild due to superior growth conditions (i.e. optimal water temperatures and inexhaustible food supply) in the laboratory. For instance, the researchers under a prior permit found that hatchery-raised abalone may become sexually mature at an age of only one year and a shell length of 25 millimeters (McCormick and Brogan, 2003). Therefore, outplanted individuals may be capable of reproducing immediately after field planting occurs. Preliminary measures of enhancement success (e.g., survival, growth, reproductive output, recruitment success, etc.) would occur immediately as opposed to waiting for another group of progeny to reach appropriate field planting sizes. Over time, the success of the field planting program could increase the numbers of recruits in the wild thereby increasing abundance and expanding the distribution of the species to areas that have not contained significant abundances of white abalone since the 1960s (i.e., shallower depths around 18-30 meters).

Past failures in California with planting juvenile and young adult abalone may in part have been due to high mortality resulting from poor release methods (Tegner and Butler, 1985, Tegner, 2000). High planting mortality was circumvented when protective shelters or planting modules were used to transfer and plant young abalone (Leighton, 1985; Leighton, 1989; Leightom, 2000). This approach appears to substantially reduce initial stocking mortality by minimizing predation and providing artificial substrate for larval settlement and adequate cover for cryptic juveniles. The use of BARMs during field planting trials should provide this type of artificial substrate and help to minimize mortality of field planted individuals. Researchers also intend to survey field sites before and after field planting to monitor for the presence of other abalone species, predators, and for evidence of diseases or other infections to minimize these threats to both the field planted colonies as well as the wild population. In addition, field sites will be monitored for the presence of members of the wild population and field planting will only occur in areas that are currently devoid of any wild white abalone to reduce threats of disease transmission as well as to minimize competitive interactions between the field planted colonies and the wild population over resources such as prey and habitat space.

Field planting techniques may be modified as a better understanding of the factors that control recruitment success emerges. If 5,000 abalone are field planted and if between 1 and 2.8 percent survive given survival rates observed during field planting trials conducted for other abalone species, then after 1 and 2 years, the number of field planted abalone would number between 50 and 140 individuals, respectively. If perfected, field planting could occur on a larger scale and ideally field planted abalone would suffer less mortality reducing the time it would take to produce self-sustaining colonies. On the other hand, if this research is not successful in identifying and instituting factors that improve the success of any propagation and field planting program, then the basic

biological knowledge of white abalone gained should outweigh the short term risks associated with introducing captive abalone into the wild. That said, field planted abalone would be mature and capable of contributing to the reproductive potential of the wild population immediately if they can successfully spawn and the larvae can successfully recruit. However, there is no way to know whether this will happen until monitoring can verify the presence of recruits. Monitoring, as proposed by the applicants, will help to verify the presence of recruits and these results will be incorporated into the research program design to improve field planting strategies and ensure that the research is beneficial and contributes to the recovery of the wild population.

Overall, the field planting activities to be conducted under the proposed permit would result in reductions in the fitness of captive white abalone that are field planted in the wild through mortality and stress from transiting to and from the grow-out facilities; however, the research is not expected to reduce the fitness of wild white abalone individuals nor would they be expected to result in adverse consequences to white abalone populations or the species as a whole. Success of the field planting program may lead to increased recruitment and expansion of the current range of the wild population thereby resulting in a potential beneficial effect to these populations as well as a reduction in the extinction risk of the species over time. Long term monitoring of the field planted colonies should inform this result.

## CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the action area considered in this Opinion. Future Federal actions, including research authorized under ESA Section 10(a)1(A), that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA. Future cumulative effects from these and other types of federal actions will be investigated in future consultations, most notably in the *Status of the Species* and *Environmental Baseline* sections of Opinions which inform the effects analyses for specific federal actions. Other possible effects that may be acting in conjunction with federal actions and could possibly contribute to a cumulative impact on listed species are described below.

NMFS expects the natural phenomena in the action area (e.g., oceanographic features, storms, natural mortality) will continue to influence survival and recruitment of white abalone as described in the *Environmental Baseline* section of this Opinion. Climatic variability has the potential to affect listed species in the action area in the future; however, the prediction of any specific effects leading to a decision on the future survival and recovery of listed species is currently speculative.

We also expect anthropogenic effects described in the *Environmental Baseline* will continue, including pollution, oil and gas activities, and illegal and unreported poaching. The number of vessels and tonnage of goods shipped by the U.S. fleet are increasing (e.g. there has been nearly a 30 percent increase in volume between 1980 and 2000) (NRC,

2003) and will lead to more vessel traffic throughout the action area in the future which could increase the possibility of fuel spills that could affect white abalone or degrade its habitat.

A future state action that is reasonably certain to occur in the action area is the redesign of California's MPA program under California's Marine Life Protection Act (MLPA). The state of California approved and signed the MLPA in 1999, directing the state to reevaluate and redesign its system of MPAs as a coherent network to protect and conserve marine life and habitats. The state is currently engaged in the MLPA planning process to evaluate and redesign MPAs along the California coast. This process has been completed for the North-Central coast (Point Arena to Pigeon Point) and Central coast (Pigeon Point to Point Conception) regions and is currently underway for the North coast (California/Oregon border to Point Arena) and the South coast (Point Conception to the California/Mexico border) regions. The MLPA process would likely result in additional protections for multiple abalone species (including white abalone and its habitat) by providing for more effective management measures and enforcement in MPAs. Thus, implementation of the MLPA would not be expected to result in cumulatively adverse effects but would rather contribute to a beneficial cumulative effect to white abalone and its preferred habitat.

Additionally, unrelated factors may be acting together to affect listed abalone species. For example, habitat degradation combined with the stresses of reduced prey availability or increased contaminant loads may reduce foraging success and lead to chronic energy imbalances and poorer reproductive success which all may work to lower an animal's ability to suppress disease. The net effect of these disturbances is dependent on the size and percentage of the population affected. the ecological importance of the disturbed area to the animals, the parameters that influence an animal's sensitivity to disturbance or the accommodation time in response to prolonged disturbance (Geraci and St. Aubin, 1980). More studies need to be done to identify the long term effects to listed white abalone from current stressors as well as the potential additive effect that multiple stressors acting in conjunction over time will have on the survival and recovery of these species.

After reviewing the available information, NMFS is not aware of any additional future non-federal activities or potential stressors reasonably certain to occur in the action area that could contribute to a cumulative impact to ESA listed species affected by the proposed action.

## INTEGRATION AND SYNTHESIS OF EFFECTS

The following text integrates and synthesizes the *Description of the Proposed Action, Approach to the Assessment, Action Area, Status of the Species, Environmental Baseline, Effects of the Proposed Action, and Cumulative Effects* sections of this Biological Opinion. This information, in addition to any known or expected cumulative effects, was used to assess the risk the proposed research activities pose to the future survival and recovery of white abalone located in the action area.

NMFS' Permits Division proposes to issue permit No. 14344 to UC Davis Bodega Marine Laboratory for research and enhancement of white abalone off the southern California coast of the U.S. pursuant to section 10(a)(1)(A) of the ESA. This permit would specifically authorize the primary researchers to maintain and expand a previously authorized captive breeding and grow-out program at four established facilities (i.e. UC Davis Bodega Marine Lab, UC Santa Barbara Marine Lab, Cabrillo Aquarium and Aquarium of the Pacific). The permit would also allow researchers to conduct experiments on captive white abalone progeny associated with genetics, reproduction, larval development, and disease as well as public display of white abalone in three public aquariums (Cabrillo Marine Aquarium, Ty Warner Sea Center, and Aquarium of the Pacific). Finally, the permit would authorize some small-scale experimental field planting at three predetermined sites off the coast of Santa Cruz Island in the Channel Islands region off southern California. The proposed permit would not authorize the collection of any white abalone from the wild and any wild-collected broodstock collected under prior permits would be reserved for captive propagation only and not be utilized in research experiments.

The proposed permit would authorize extensive "take" associated with large scale white abalone cultivation. Researchers will be working with tens of thousands of animals at a time at all life stages. Abalone in captivity would be expected to experience routine mortality associated with life history events as well as mortality and stress associated with research activities and experimental field planting. The only activities that will occur outside of the captive environment will be experimental field planting of captive progeny. Experimental field planting will occur at three sites located on the south side of Santa Cruz Island in the Channel Islands National Marine Sanctuary and Channel Islands National Park (along the Yellow Banks outside of the protected Gull Island Reserve area). Researchers will utilize up to 12 existing Baby Abalone Recruitment Modules (BARMs) that were designed for white abalone restoration. Field planting will involve the release of disease- and parasite-free abalone as late-stage larvae, smaller juveniles, advanced juveniles, and young adults. Researchers will screen all individuals for disease and parasites prior to transport and every attempt will be made to place outplanted progeny within the known geographic range of parents but isolated from extant populations to prevent competition and unexpected disease transmission. A minimum of 5,000 progeny from each year class would be raised to maturity for field planting. Researchers will monitor outplanted abalone to determine effects of density and size as well as habitat and benthic community on survival.

As explained in the *Approach to the Assessment* section, risks to listed individuals are measured using changes to an individual's "fitness." When listed plants or animals exposed to an action's effects are not expected to experience reductions in fitness, we would not expect the action to have adverse consequences on the viability of the populations those individuals represent or the species those populations comprise (e.g., Brandon, 1978; Mills and Beatty, 1979; Stearns, 1992; Anderson, 2000). When individuals of listed plants or animals are expected to experience reductions in fitness in response to an action, those fitness reductions can reduce the abundance, reproduction, or growth rates of the populations that those individuals represent (see Stearns, 1992). If we

determine that reductions in individual plants' or animals' fitness reduce a population's viability, we consider all available information to determine whether these reductions are likely to appreciably reduce the viability of the species as a whole.

As discussed in the *Status of the Species* section, White abalone are suffering from recruitment failure and individuals observed in the wild are currently not in sufficient densities or are too far apart to support successful fertilization at levels measured for other abalone species (Babcock and Keesing, 1999; Butler et al., 2006). Abalone populations declined nearly 99 percent in the 1970's due to extensive commercial exploitation and the remaining individuals continue to face threats to their survival due to poaching, climate variability, and other natural threats such as predation. If the remaining white abalone are reproductively isolated, the number of individuals that die or emigrate from the population will over time exceed the number born or immigrating into the population and, thus, the population will decline to extinction.

Taken together, the components of the environmental baseline for the action area include sources of natural mortality – such as predation, disease, and parasites – as well as influences from natural oceanographic and climatic features in the action area. The baseline also includes human activities resulting in disturbance, injury, or mortality of individuals. These activities include the persistent effects felt from the historical commercial harvest of white abalone populations, poaching, habitat degradation (e.g., due to sediments and heavy metal contamination), and oil and gas structures. Conservation and management efforts are ongoing and are expected to have a positive effect on the status of listed species found within the action area.

It is expected that captive white abalone will experience mortality at every life stage in order to achieve the research objectives. For those that do not die over the duration of the permit, many will experience varying degrees of stress and trauma as a result of captive maintenance and handling, research experiments, and during transit to and from research and grow-out facilities as well as field plant sites. Over time as the captive population expands and densities in the captive setting increase, captive individuals may experience decreased growth rates and a lower suppression for disease as has been measured for other species under high density conditions (Clarke and Creese, 1998). There is also the threat of disease outbreaks (e.g. withering syndrome) and/or parasite infections (e.g. sabellid worm infestation) that have already caused catastrophic losses of individuals under the previous permit. Mitigation measures have been developed that should reduce the risk of captive-bred animals becoming infected with disease or parasites, increase the reproductive potential of field planted animals, and reduce the risks of introducing disease and parasites into the wild during field planting trials. Therefore, while adverse fitness consequences are likely to occur to individual abalone in the form of mortality and stress associated with the captive propagation and research program, long term threats to the entire captive population are unlikely and will not result in adverse consequences for the wild population or the species as a whole.

The researchers' goal for the experimental field planting program is to maintain at least 5,000 captive white abalone each year to be field planted at predetermined sites with the

intent to eventually establish successfully reproducing colonies. Higher numbers of abalone may be field planted depending on the success of the captive propagation program with a maximum of 50,000 adults, 100,000 juveniles, and 2,000,000 larvae authorized to be field planted in a given year. While the success of a captive propagation and field planting program for white abalone is uncertain (Burton and Tegner, 2000; McCormick, 2000; Tegner, 2000), preliminary data suggests that the captive propagation could produce progeny that reach reproductive maturity faster than expected in the wild due to superior growth conditions (i.e. optimal water temperatures and inexhaustible food supply) in the laboratory. Over time, the success of the field planting program could increase the numbers of recruits in the wild thereby increasing abundance, and expanding the distribution of the species to areas that have not contained white abalone since the 1960s (i.e., shallower depths around 18-30 meters).

The use of BARMs during field planting trials should provide artificial substrate and help to minimize mortality of field planted individuals. Researchers also intend to survey field sites before and after field planting to monitor for the presence of other abalone species, predators, and for evidence of diseases or other infections to minimize these threats to both the field planted colonies as well as the wild population. In addition, field sites will be monitored for the presence of members of the wild population and field planting will only occur in areas that are currently devoid of any wild white abalone to reduce threats of disease transmission and/or competitive interactions between the field planted colonies and the wild population. Overall, the field planting activities to be conducted under the proposed permit would result in reductions in the fitness of captive white abalone that are field planted in the wild through mortality and stress from transiting to and from the grow-out facilities; however, the research is not expected to reduce the fitness of wild white abalone individuals nor would they be expected to result in adverse consequences to white abalone populations or the species as a whole. The survival of field planted abalone is intended to generate self-sustaining colonies of white abalone in areas that once supported members of the wild population. Over time, these colonies would be expected to recruit into the wild population and expand the range of the wild population, thereby resulting in a beneficial effect to the wild population and the species as a whole.

NMFS expects the natural phenomena in the action area (e.g., climate variations, natural mortality) will continue to influence white abalone throughout its range. Climatic variability has the potential to affect the wild population through alteration of community composition and structure, increased susceptibility to disease and contaminants, alterations to prey composition, and altered timing of breeding. We also expect anthropogenic effects described in the *Environmental Baseline* will continue, including habitat degradation, poaching, and increased threat of disease. The net effect of these disturbances is dependent on the size and percentage of the population affected, the ecological importance of the disturbed area to the animals, the parameters that influence an animal's sensitivity to disturbance, or the accommodation time in response to the prolonged disturbance. More studies need to be done to identify the long term effects to listed white abalone from current stressors as well as the potential additive effect that multiple stressors acting in conjunction over time have on the survival and recovery of these species in the future.

Based on the best scientific information available, we expect that responses to the research activities as proposed is likely to reduce the fitness of captive white abalone individuals through mortality and stress; however, we do not expect any long-term adverse consequences to white abalone populations either in the captive environment or in the wild nor would they contribute to a significant cumulative effect. Success of the field planting program may lead to increased recruitment and expansion of the current range of the wild population thereby resulting in a potential beneficial effect to these populations as well as a reduction in the extinction risk of the species over time. Long term monitoring of the field planted colonies should inform this. As a result, we do not expect activities authorized by the proposed permits to have an appreciable adverse effect on the extinction risk of the population(s) these individuals represent or the species those populations comprise.

## CONCLUSION

After reviewing the current status of listed species affected by the proposed action, the environmental baseline for the action area, the anticipated effects of the proposed research activities and the possible cumulative effects, it is the Endangered Species Division's opinion that the Permits Division's proposed action of issuing permit No. 14344 to the UC Davis Bodega Marine Laboratory, as proposed, is not likely to jeopardize the continued existence of white abalone. In addition, no designated critical habitat under NMFS' authority would be affected.

## INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and federal regulation pursuant to section 4(d) of the ESA prohibit the "take" of endangered and threatened species, respectively, without special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by the NMFS to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of Sections 7(b)(4) and 7(o)(2), taking that is incidental and not intended as part of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement. However, as discussed in the accompanying Opinion, only the species targeted by the proposed research activities will be affected as part of the intended purpose of the proposed action. Therefore, NMFS does not expect the proposed action will incidentally take threatened or endangered species.

## CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans or to develop information.

The Endangered Species Division is including the following conservation recommendation, which would provide information for future consultations involving endangered white abalone:

1. Before issuing permits with similar actions, the Permits Division should review all annual and final reports submitted by investigators and use this information to estimate the amount of mortality that occurs in the captive setting as well as in the field. This information should then be used to better estimate actual levels of "take" for future permits.

In order for the Endangered Species Division to be kept informed of actions minimizing or avoiding adverse effects on, or benefiting, listed species or their habitats, the Permits Division should notify the Endangered Species Division of any conservation recommendations they implement in their final action.

## REINITIATION NOTICE

This concludes formal consultation and conference on the proposal to issue scientific research permit No. 14344 to the UC Davis Bodega Marine Laboratory for research on ESA listed white abalone off the U.S. west coast. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of proposed take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this Opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this Opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of authorized take is exceeded, NMFS Office of Protected Resources – Permits, Conservation, and Education Division must immediately request reinitiation of section 7 consultation.

You may ask NMFS to confirm the conference opinion as a biological opinion issued through formal consultation if the North Pacific Ocean DPS for loggerhead sea turtles is listed and areas proposed as critical habitat for the leatherback sea turtle and black abalone are designated. The request must be in writing. If NMFS reviews the proposed action and finds that there have been no significant changes in the action as planned or in the information used during the conference, NMFS will confirm the conference opinion

as the biological opinion on the project and no further section 7 consultation will be necessary.

After the North Pacific Ocean DPS for loggerhead sea turtles is listed and areas proposed for critical habitat for the leatherback sea turtle and black abalone are designated and any subsequent adoption of this conference opinion, the Federal agency shall request reinitiation of consultation if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect the species or critical habitat in a manner or to an extent not considered in this conference opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the species or critical habitat that was not considered in this conference opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action.

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